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AUSTRALIAN PYCNOGONIDA

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(Figs 1-38) Manuscript received 15.7.62

ABSTRACT

A large collection of Pycnogonida from the Australian Museum has been examined. Of the 42 species represented 22 are new, and many others belong to species hitherto known from single specimens, or from one sex only. The following new species are described and figured: *Nymphon molleri* n. sp., *N. novaehollandiae* n. sp., *N. bunyipi* n. sp., *Oropallene minor* n. sp., *Parapallene obtusirostris* n. sp., *Pseudopallene dubia* n. sp., *Stylopallene cheilorhynchus* n. gen. et sp., *S. dorsospinum* n. sp., *S. tubirostris* n. sp., *Pallenopsis macneilli* n. sp., *Anoplodactylus evansi* n. sp., *A. simplex* n. sp., *Ascorhynchus compactum* n. sp., *Ammothella stocki* n. sp., *A. thetidis* n. sp., *Cilunculus australiensis* n. sp., *C. hirsutus* n. sp., *Pycnogonum torresi* n. sp., *P. tuberculatum* n. sp. Two new species of *Anoplodactylus* are described but not named (females only), and a new form of *Callipallene* is also described, but because of the confused state of the taxonomy of this genus in Australian waters it has not been named.

A check-list of all 62 species recorded from the Australian region is included.

INTRODUCTION

Studies on the Pycnogonid fauna of Australia have been few and sporadic. The majority of studies have been undertaken by workers outside Australia, and as a result all studies have been purely systematic. No information is available on the biology of Australian species. The first work of any note was that of Hoek (1881), which resulted from the Challenger Expedition and which also provided the inspiration for Haswell's paper of 1884. Nothing further was done until Flynn's series of papers (1919a, 1919b, 1920, 1929). After Flynn left Australia, material continued to be sent to him and this was described by his colleague Williams (1933, 1940, 1941). There have also been short papers by Loman (1923) and Hedgepeth (1944). The most important paper of recent times is Stock's (1954) report on the material collected by the Mortensen Expedition.

The present study is based on a large collection of Pycnogonida in the Australian Museum which was made available to me by the kindness of the Director, Dr. J. W. Evans. This collection has been amassed over the past 80 years, and the excellent state of preservation of the collection as a whole says much for the curation it has received.

The Australian Museum collection I have examined consists of 808 specimens referrable to 42 species belonging to 18 genera. Of these, 22 species are new to science, and many represent species hitherto known from a single specimen or from specimens of one sex. This abundant material has permitted me to re-describe many species and to provide more detailed figures of a number of others. Even with this large collection it is still not possible to confidently delimit some species, especially in the genera *Callipallene* and *Achelia*. Larger collections of these genera are desirable.

The bulk of the material is from the New South Wales coast, the region which is already best known in this respect. Even so, this collection has increased the number of known Australian species from 40 to 62. Figure 1 shows all the localities in Australia from which these animals have been recorded. South-eastern Australia

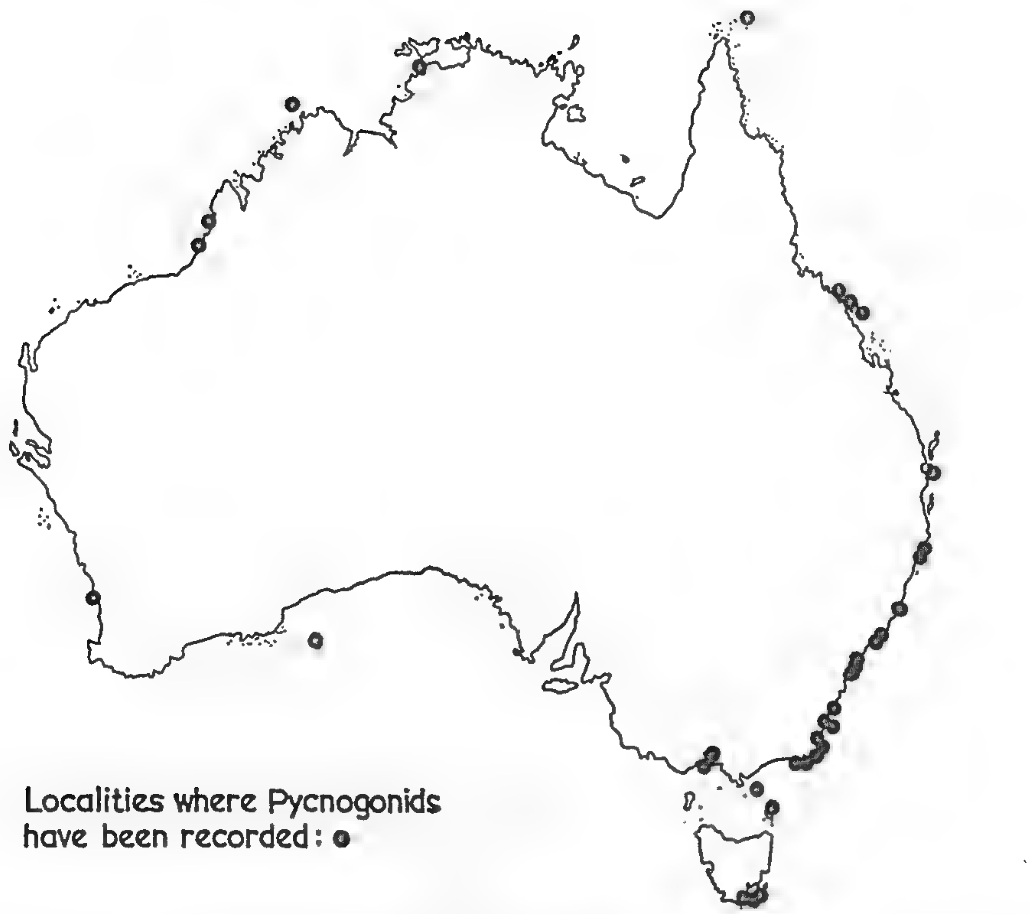

Fig. 1.—Map showing the Australian localities where pycnogonids have been collected and reported. Localities mentioned in this paper are included.

is fairly well covered by comparison with the rest of Australia. It is a striking fact that no pycnogonids have been recorded from Port Philip westwards to Rottnest Island, Western Australia, and only three species between Rottnest Island and the Gulf of Carpentaria. It is probable that careful shore collecting in any part of the country would increase the number of short-legged littoral forms which often tend to the production of local species.

THE AUSTRALIAN FAUNA

As far as it is possible to speak of an Australian fauna in the present state of comparative ignorance, the Australian region appears to be characterized by an abundance of genera and species in the Callipallenidae, many of which are endemic or appear to have the centre of their distribution in the Australian region or in the Austro-Malayan region. In this connection the distribution of the genus *Parapallene* Carpenter as discussed by Stock (1953, 1956b) is interesting. The only exception to the West Pacific—Indian Ocean distribution of this genus is the inadequately described *P. bermudensis* Lebour, 1949. A very similar distribution is found for *Pseudopallene* Wilson, which has one species widely distributed in Arctic seas. The smaller genera also show this type of distribution. An interesting type of distribution is that shown by the species of *Oropallene* Schimk. and *Anoropallene* Stock, with *Oropallene* being mainly Australian in distribution and *Anoropallene* mainly restricted to the Pacific coast of North America. *Anoropallene valida* (Hasw.), which appears to be transitional between the two genera, is most interesting in this case.

The Ammotheidae of Australia are of interest because of the number of species of *Cilunculus* Loman and *Ammothella* Verril. *Cilunculus* generally shows a similar distribution pattern to *Parapallene*, and *Ammothella* is similar to *Pseudopallene*.

At present there is little more to be said on this matter until more is known of the rest of the Commonwealth.

GENERAL REMARKS

All material has been returned to the Australian Museum and the types are deposited in that institution. In the lists provided under the heading "Material" in the descriptions the combination of a letter and figures which follows the letters A.M. is the Australian Museum registration number.

Because few zoologists are familiar with these animals I have included (fig. 2) a figure of a *Nymphon* sp. and labelled it fully to illustrate the terminology used in the descriptions and to enable others to use the keys provided. Pycnogonids are usually preserved in tubes of 70 per cent. alcohol. The tubes should not be stoppered with cotton-wool plugs as the claws become hopelessly entangled in this, and there is great danger of damage to the specimens in extricating them. Such plugs are best wrapped in tissue paper. When collecting pycnogonids growths of hydroids are usually good places to search, as a number of species feed on hydroids, and some are parasitic within them in the larval stages.

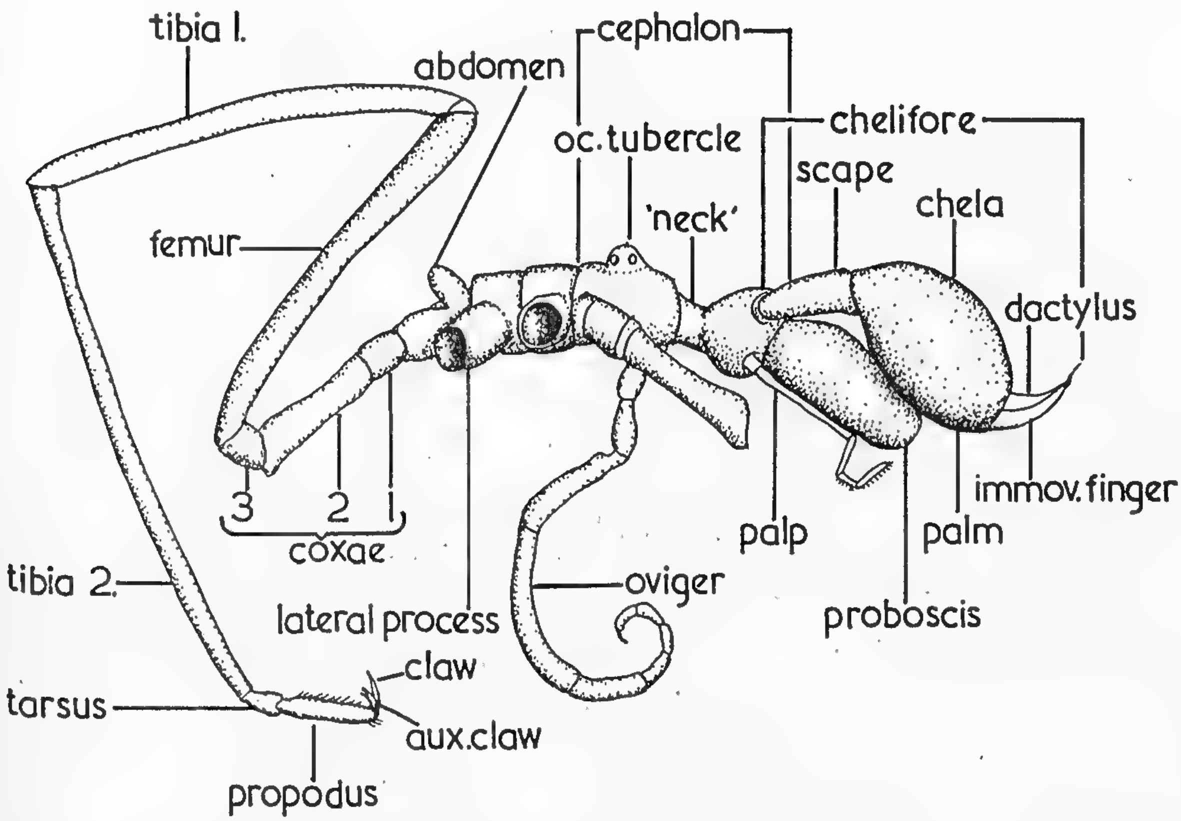

Fig. 2.—A diagrammatic figure of a *Nymphon* sp. to illustrate the terminology used in the descriptions and keys.

ACKNOWLEDGEMENTS

I should like to express my gratitude to Dr. J. W. Evans, Director of the Australian Museum, for entrusting this collection to me, and to Mr. F. A. McNeill, of the same institution, for consulting types and answering many queries. Thanks are also due to the Director of the British Museum and Dr. Isabella Gordon for facilities enjoyed there while examining type material, and also for permission to describe the female of *Parapallene famelica* Flynn.

CHECK-LIST OF AUSTRALIAN PYCNOGONIDA

(* Indicates Species not Represented in Collection)

NYMPHONIDAE

Nymphon aequidigitatum Haswell, 1884
Nymphon immane Stock, 1954
Nymphon singulare Stock, 1954
Nymphon molleri n. sp.
Nymphon novaehollandiae n. sp.
Nymphon bunyipi n. sp.

CALLIPALLENIDAE

Anoropallene valida (Haswell, 1884)
Oropallene minor n. sp.
Callipallene emaciata micrantha Stock, 1954
Callipallene brevirostris novaezelandiae (Thomson, 1884)*
Callipallene sp.
Parapallene australiensis (Hoek, 1881)
Parapallene challengeri Calman, 1937*
Parapallene famelica Flynn, 1929
Parapallene haddoni Carpenter, 1892
Parapallene obtusirostris n. sp.
Parapallene (?) *aculeata* Stock, 1954*
Metapallene languida (Hoek, 1881)*
Pallenella laevis (Hoek, 1881)*
Pseudopallene ambigua Stock, 1956
Pseudopallene pachycheira (Haswell, 1884)*
Pseudopallene dubia n. sp.
Stylopallene cheilorhynchus n. gen. et sp.
Stylopallene dorsospinum n. sp.
Stylopallene tubirostris n. sp.
Pallenopsis denticulata Hedgepeth, 1944*
Pallenopsis gippslandiae Stock, 1954
Pallenopsis hoekii Miers, 1884
Pallenopsis macneilli n. sp.
Pycnothea flynni Williams, 1940

PHOXICHILIDIIDAE

Anoplodactylus longiceps Stock, 1954* (= *A. longicollis* Williams, 1941 preocc.)
Anoplodactylus haswelli (Flynn, 1919)
Anoplodactylus tubiferus (Haswell, 1884)
Anoplodactylus evansi n. sp.
Anoplodactylus simplex n. sp.
Anoplodactylus spec. A.
Anoplodactylus spec. B.

AMMOTHEIDAE

Ammothea australiensis Flynn, 1919
Achelia aspersa Loman, 1923*
Achelia assimilis (Haswell, 1884)
Achelia australiensis Stock, 1954
Achelia variabilis Stock, 1954
Nymphopsis acinacispinatus acinacispinatus Williams, 1933*
Nymphopsis acinacispinatus bathursti Williams, 1940*
Nymphopsis armatus Haswell, 1884*
Ascorhynchus longicollis Haswell, 1884
Ascorhynchus melwardi Flynn, 1929*
Ascorhynchus minutum Hoek, 1881
Ascorhynchus tenuirostris Carpenter, 1892*
Ascorhynchus compactum n. sp.
Ammothella biunguiculata australiensis Williams, 1940
Ammothella stocki n. sp.
Ammothella thetidis n. sp.
Cilunculus australiensis n. sp.
Cilunculus hirsutus n. sp.
Tanystylum orbiculare Wilson, 1878

COLOSSENDEIDAE

Colessendeis macerrima Wilson, 1881
Rhopalorhynchus clavipes Carpenter, 1893*
Rhopalorhynchus tenuissimum (Haswell, 1884)*

PYCNOGONIDAE

Pycnogonum aurilineatum Flynn, 1919*
Pycnogonum torresi n. sp.
Pycnogonum tuberculatum n. sp.

INCERTAE SEDIS

Parapallene chiragra (Milne-Edwards, 1840) not sufficiently well described to be recognizable; the types have been lost; see remarks under *Parapallene australiensis*.
Phoxichilidium charybdaeus of Haswell, 1884, is not *Endeis charybdaeus* (Dohrn.). Haswell's specimen was a juvenile which is not identifiable at present.
Phoxichilidium plumulariae Lendenfeld, 1883, from Melbourne (Port Philip?) is a larva which cannot be associated with any known adult.
Austrodecus glaciale Hodgson, recorded very doubtfully by Gordon (1944, p. 6) from south of Tasmania, is such a doubtful record (see Stock, 1957, footnote to p. 46) that it can hardly be discussed further at this stage.
Pycnogonum australe Grube, 1869, is based on a larva with three pairs of legs and traces of a fourth pair. It is not recognizable at present.

Family **Nymphonidae** Wilson, 1878

Genus **Nymphon** J. C. Fabricius, 1794

Nymphon aequidigitatum Haswell

Figs. 3 A—G

Nymphon aequidigitatum Haswell, 1884; 1022-1024, pl. 54, figs. 1-5. ——Whitelegge, 1889; 233. ——Loman, 1908; 38. ——Flynn, 1919b; 72-75, pl. XVIII, figs. 4-5, pl. XIX, fig. 6.

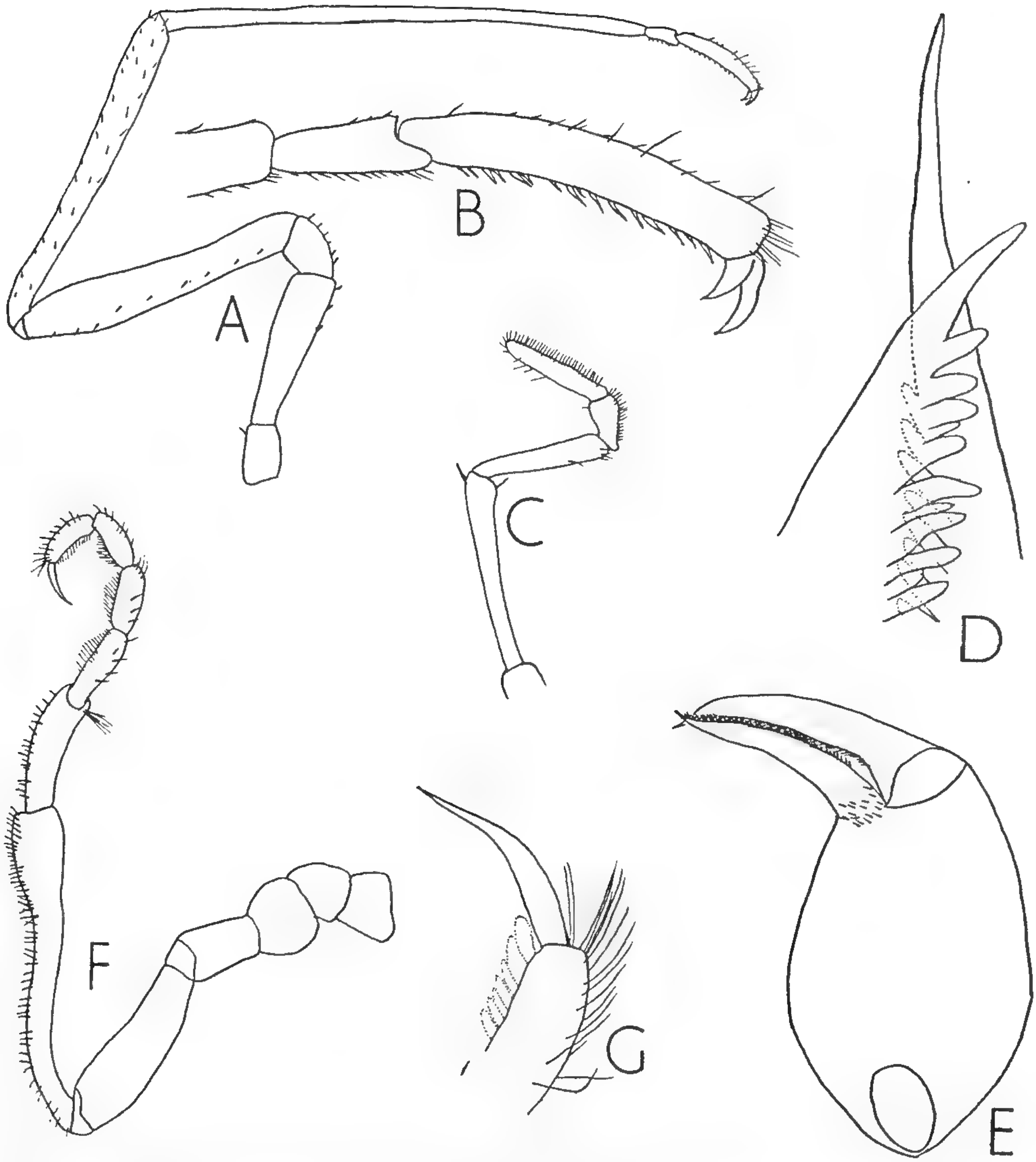

Fig. 3.—A-G, *Nymphon aequidigitatum* male. A, third leg; B, propodus; C, palp; D, detail of tip of chela; E, chela; F, oviger; G, tip of oviger.

MATERIAL

3 males, Shark Island, Port Jackson, N.S.W., A.M. P.3253 (part).

1 male, Nelson's Bay, Port Stephens, N.S.W., A.M. P.13586.

1 female, Shark Island, Port Jackson, N.S.W., coll. C. Hedley and A. R. McCulloch, A.M. P.2112 (One of two specimens mounted on a microscope slide.)

3 males, 3 females, 8 immature, Shark Island, Port Jackson, N.S.W., coll. C. Hedley and A. R. McCulloch, 1909. A.M. P.2113 (part).

1 male, 1 female, Port Jackson, N.S.W., A.M. P.3250.

1 male, Port Jackson, N.S.W., A.M. P.3251.

REMARKS

This species has been satisfactorily redescribed by Flynn (1919), but since some of the detailed figures are rather inadequate new ones have been prepared. These differ a little from the figures of the type; the palm of the chela is more inflated than appears from the earlier figures; the spine formula of the male ovigers examined is 15: 14: 13: 14. The hairs on the fifth and sixth oviger joints are much shorter than shown in Haswell's figure. The male genital pores are on the ventral surface of the second coxae of the third and fourth pair of legs.

Nymphon immane Stock.

Figs. 4 A—B

Nymphon immane Stock, 1954: 25-28, figs. 9-10.

MATERIAL

1 female, about 28 miles off Port Jackson, N.S.W., on edge of continental shelf, 540 metres. A.M. P.13587.

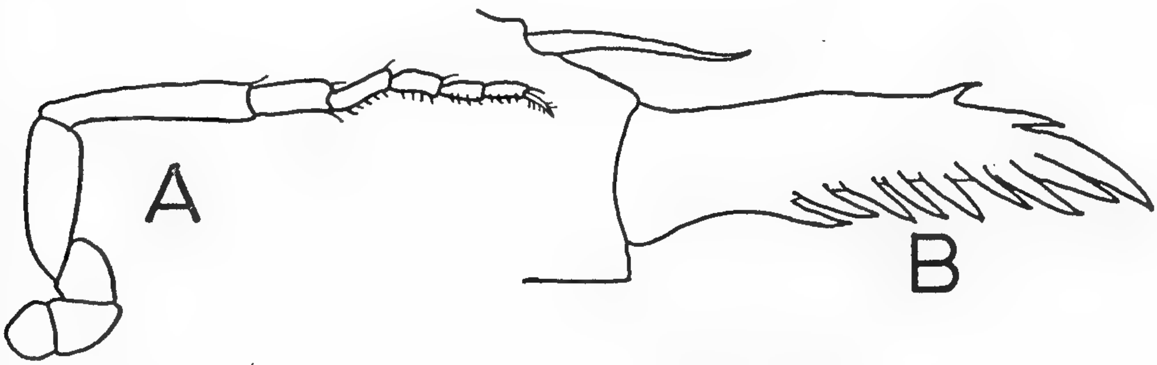

Fig. 4.—A-B, *Nymphon immane*, female. A, oviger; B, terminal claw of oviger.

REMARKS

This is the first female, and indeed only the second specimen of this species to be recorded. The specimen agrees perfectly with Stock's figures and description, differing only, as is to be expected, in the structure of the oviger. The female oviger is 10-jointed, the fifth joint is the longest, but is relatively not as long as in the male, nor is it clavate or strongly curved. Setae are lacking except for a small one at the distal end. The spine formula is 5: 4: 4: 4. The terminal claw has two spines on the outer margin instead of one as in the holotype.

This female is a little larger than the male, measuring 4·25 mm. from the tip of the cephalic segment to the tip of the abdomen, as compared with 3·67 in the male.

Nymphon singulare Stock

Nymphon singulare Stock, 1954: 21-25, figs. 7-8.

MATERIAL

1 male, off Twofold Bay, N.S.W., 81-90 metres, coll. Capt. K. Moller, trawler "Durraween", Aug., 1929. A.M. P.13588.

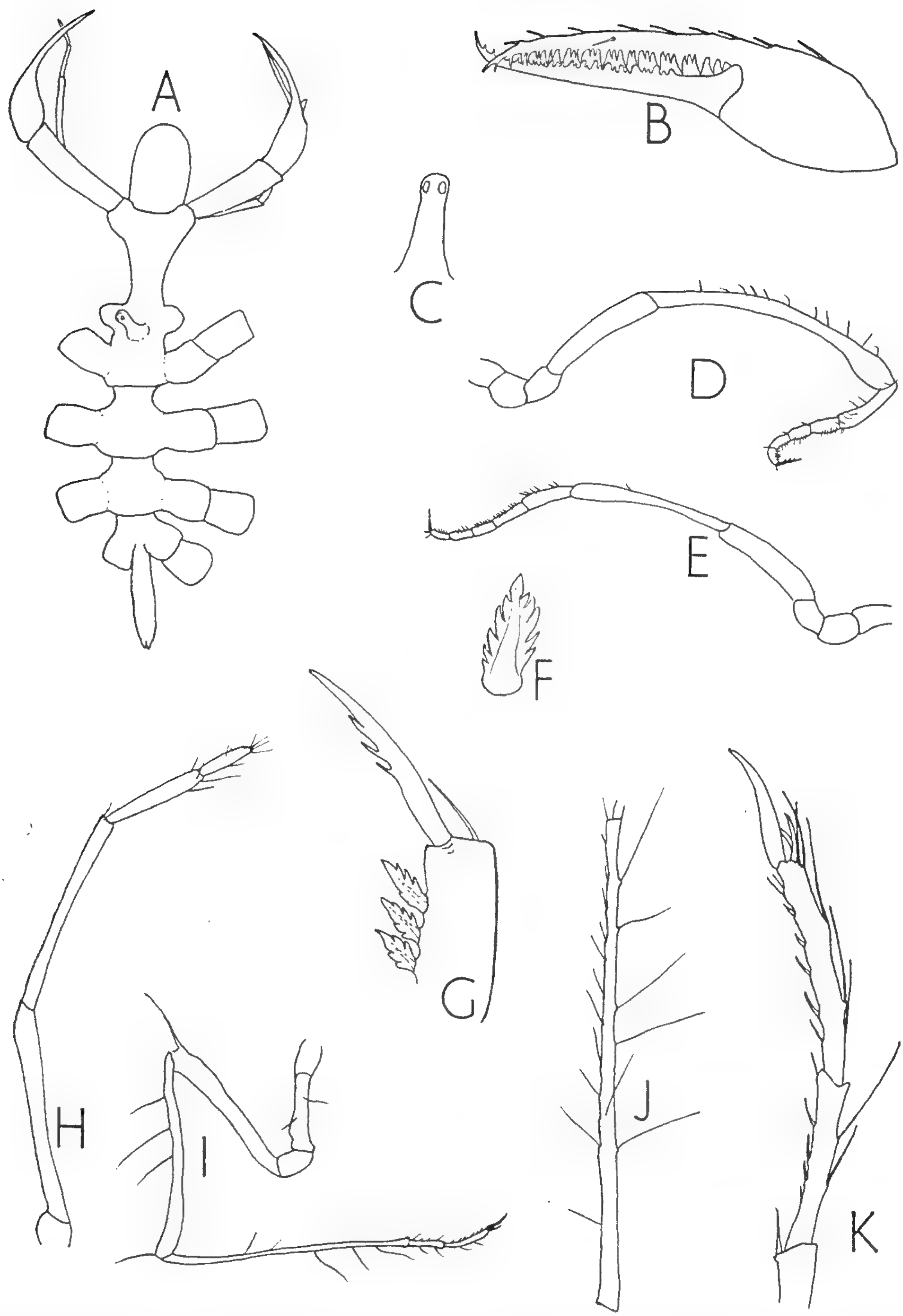

Fig. 5.—A-K, *Nymphon bunyipi.* All figures of a male paratype, except E. A, dorsal view of trunk; B, chela; C, ocular tubercle; D, male oviger; E, female oviger; F, male oviger spine; G, tip of male oviger; H, palp; I, third leg; J, second tibia; K, propodus.

REMARKS

The one adult male in the collection fits Stock's description perfectly, and there is nothing that can be added to it. This species is undoubtedly closely allied to *Nymphon novaehollandiae* n. sp., but is readily distinguished from that species by the total absence of a narrow neck region, the much closer spacing of the chelifore bases, and the lack of tubercles on the first coxae.

Nymphon bunyipi n. sp.

Figs. 5 A—K

MATERIAL

66 males (1 is the holotype), 56 females (1 is allotype), 1 juvenile, off Cape Everard, Victoria, 126-135 metres, trawled, coll. H. O. Fletcher, May, 1929. A.M. P.13589, P.13590, P.13591.

73 males, 55 females, 4 juveniles, Station 57 "Thetis" Expedition, 3½-4 miles off Wata Mooli, near Botany Bay, N.S.W., 96-105 metres, dredged. A.M. P.13592.

1 male, 4 females, Station 37 "Thetis" Expedition, 2-2½ miles off Botany Bay, N.S.W., dredged 90-93 metres. A.M. P.13593.

1 male, 1 female, 5 miles off Green Cape, 81 metres, trawled, coll. K. Moller, May, 1930. A.M. P.13594.

1 male, 1 female from conglomerate boulder taken by trawler "Goonambee" about lat. 33° 44′ S., long. 151° 38′ E. (about 16-18 miles north-east of South Head of Port Jackson, N.S.W.), 135-144 metres, coll. C. W. Mulvey, May, 1924. A.M. P.13595.

1 male, 1 female, off Wata Mooli, N.S.W., 88-90 metres, "Thetis" Expedition, 1898, found intermingled with hydrozoa and polyzoa. A.M. P.13956.

DESCRIPTION

Trunk moderately robust, anterior lateral processes separated by about their own width; posterior ones may be closer together. Integument smooth, without spines or tubercles. Cephalon long; equal to remaining trunk segments; with a moderate neck region which is expanded anteriorly to provide for insertion of proboscis, chelifore scapes and palps. Oviger bases arise as cervical processes a little anterior to first lateral processes, and slightly anterior to ocular tubercle. Narrowest part of neck a little narrower than proboscis.

Ocular tubercle moderately tall, two and a half times as high as diameter at base; flattened on top, sides concave, four eyes.

Proboscis cylindrical, twice as long as wide, rounded at tip.

Abdomen elevated at an angle of about 30°, cylindrical, tapering towards tip, reaching beyond ends of first coxae.

Chelifores: scape one-jointed, smooth, wider distally than proximally, chela with fingers longer than palm, with a row of small spines along outer edge of immovable finger. Fingers curved at tips, tips cross slightly; teeth of immovable finger, in central portion at least, arranged in alternate series of two small ones and one large one; teeth uniform in size distally. All teeth sharply pointed.

Palps five-jointed, basal joint short, second and third joints long, fourth and fifth decreasing in size and beset with a few setae.

Oviger 10-jointed in both sexes; joints 1-3 short, fifth joint longest; arcuate and clavate in male, less so in female, joints 7-10 decreasing in size and beset with denticulate spines. The fifth joint in the male bears a number of setae along its

length; the seventh joint bears two moderately stout simple spines and four denticulate ones in the same row. If this situation be represented by the notation (2 + 4), then the spine formula of joints 7-10 in the male is (2 + 4) : 5 : 4 : 5 or (2 + 5) : 5 : 4 : 5, and (3 + 5) : 6 : 4 : 5 in the female. Measurements of the oviger joints in mm.:—

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·225	0·285	0·3	0·825	1·65	0·39	0·225	0·15	0·12	0·135
Female ..	0·21	0·255	0·3	0·75	1·0	0·39	0·27	0·18	0·135	0·135

Third Leg slender, somewhat hairy; second coxa longer than first and third combined; femur one of the stoutest joints with a long and prominent seta on the dorsal distal extremity; first tibia longer and more slender than femur, somewhat arcuate, with a dorsal border of a few long setae; second tibia the longest and most slender of the long joints, with a number of long setae. Tarsus three-quarters as long as propodus; propodus with fine spines on sole, claw more than half as long as propodus, auxiliary claws less than half as long as main claw.

Genital Pores on slight swellings on distal part of ventral surface of all second coxae in the female, but only on the third and fourth pairs in the male.

Measurements (in mm.): length trunk (anterior margin of cephalon—tip of abdomen) 3·3, length of cephalon 1·35, width second lateral processes 1·3, length of chelifore scape 0·75, length of proboscis 0·75, greatest width of proboscis 0·4, length of abdomen 0·7. Third leg: 1st coxa 0·4, 2nd coxa 1·0, 3rd coxa 0·5, femur 2·1, 1st tibia 2·65, 2nd tibia 3·12, tarsus 0·45, propodus 0·6, claw 0·36, auxiliary claw 0·15.

REMARKS

This species is easily recognized by the short palm and the spination on the fingers of the chelae. In sorting mixed collections, the setose limbs, especially the second tibia, are a useful character. The general form of the trunk resembles *N. arabicum* Calman, 1938, and *N. pixellae* Scott, 1913, but is readily distinguished from these species by the greater length of the abdomen and the structure of the chela. The male ovigers of *N. bunyipi* and *N. pixellae* are very similar.

Nymphon molleri n. sp.

Figs. 6 A—H

MATERIAL

3 females (1 is holotype) Shark Island, Port Jackson, N.S.W., coll. C. Hedley and A. McCulloch, 1909. A.M. P.2113 (part).

2 females Port Jackson, N.S.W. (Old Collection). A.M. G.5173.

1 female, Shark Island, Port Jackson, N.S.W., coll. C. Hedley and A. R. McCulloch (one of two specimens mounted on a microscope slide) A.M. P.2112 (part).

DESCRIPTION

Trunk smooth, without spines or tubercles; lateral processes well spaced, separated distally by one and a half times their own width. Neck long and narrower than proboscis, expanded distally to provide articulations for chelifore scapes, with

a slight median furrow between these. The cervical processes arise very close to the anterior margin of the first lateral processes.

Ocular tubercle low, rounded above, in lateral view appears flattened above; two small tubercles are seen in front view. Tubercle situated over anterior part of first lateral processes and posterior part of cervical processes. Four large eyes present.

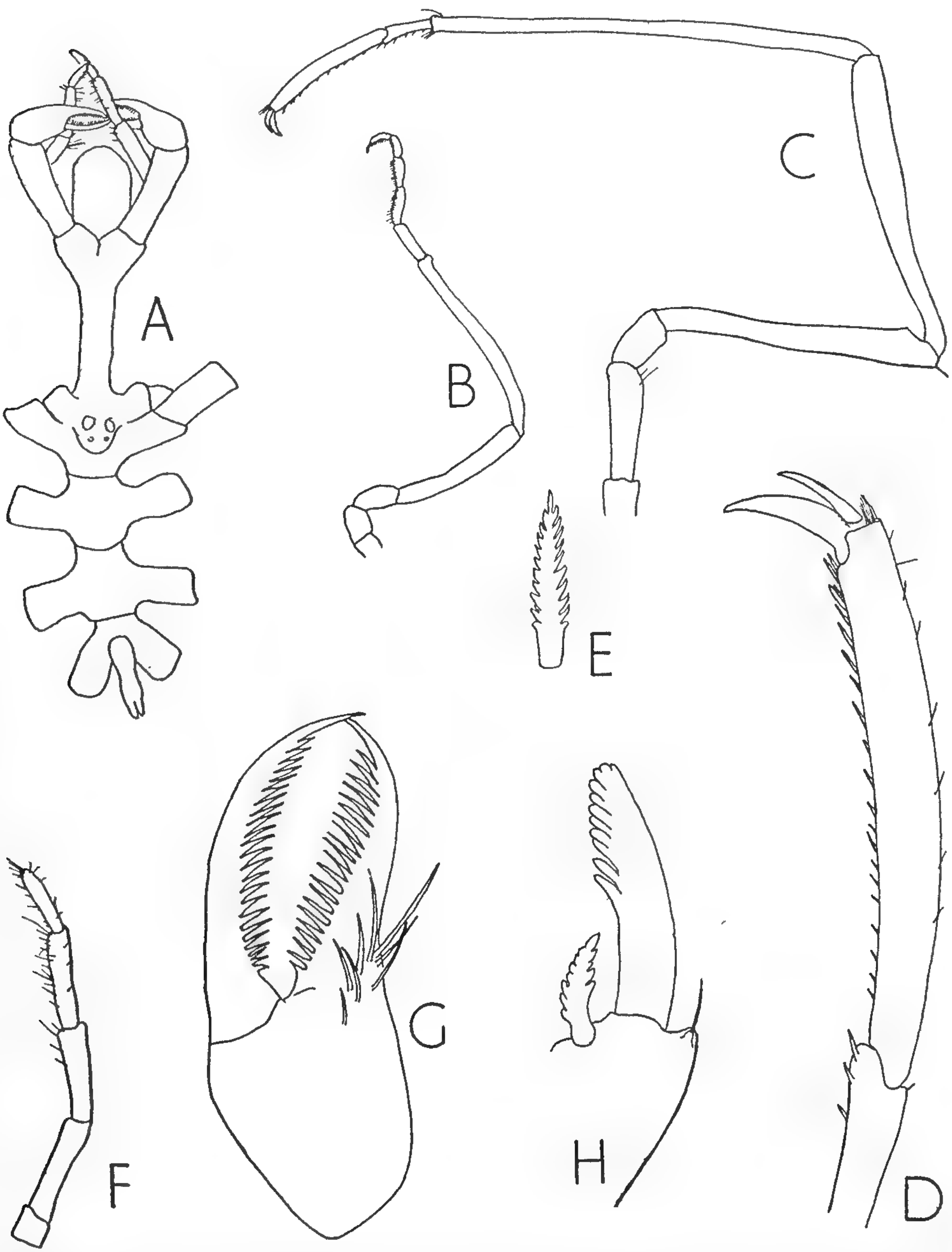

Fig. 6.—A-H, *Nymphon molleri.* A, dorsal view of trunk; B, male oviger; C, male third leg, D, propodus; E, oviger spine; F, palp; G, chela; H, tip of oviger.

Proboscis stouter than neck, cylindrical; slightly inflated in distal half, tip rounded.

Abdomen reaching a little beyond tip of fourth lateral processes, set at an angle of 35° to dorsum; with a slight constriction about middle, tapering towards tip, anus terminal.

Chelifore scape one-jointed, smooth, chelae with fingers a little longer than palm, bowed, tips cross when fingers closed. Teeth long, slender, regular, 23 on dactylus, 21 on immovable finger. A group of setae present at base of immovable finger.

Oviger (female) 10-jointed, first three joints short, fifth joint longest, fourth joint the second longest; joints 6-10 decreasing in length. Lengths of joints (in mm.): 1—0·26, 2—0·45, 3—0·55, 4—1·75, 5—2·4, 6—0·75, 7—0·47, 8—0·73, 9—0·33, 10—0·3. Denticulate oviger spines present on joints 7-10 according to formula 14 : 12 : 10 : 10. Terminal claw present; bluntly denticulate through distal half of inner edge only.

Third leg slender, almost without setae on the long joints; second coxa longer than first and third combined, femur slender and shorter than either tibia. Second tibia the longest joint, without setae except at distal extremity; first tibia intermediate in length. Tarsus about one-third as long as propodus with small spines on ventral margin; propodus slightly curved with small simple spines on sole; main claw about one-quarter the length of propodus, auxiliary claws four-fifths as long as main claw.

Genital pores (female) on ventral surface of distal ends of all second coxae.

Measurements (in mm.): length of trunk (tip of cephalon to tip abdomen) 4·35, length cephalon 2·14, width second lateral processes 1·65, length of proboscis 0·78, greatest width of proboscis 0·47, length of chelifore scape 1·85, length of abdomen 0·7. Third leg: 1st coxa 0·4, 2nd coxa 1·4, 3rd coxa 0·8, femur 3·4, 1st tibia 3·8, 2nd tibia 5·33, tarsus 0·6, propodus 1·73, claw 0·37, auxiliary claw 0·3.

REMARKS

This species is named in honour of Captain K. Moller, whose industry in collecting Australian pycnogonids will be obvious to all readers of this report. This species is easily distinguished from all other known Australian species of *Nymphon* by the presence of the long neck and the characteristic form of the chelae. *N. molleri* is rather similar to *N. angolense* Gordon, 1932, in the general appearance of the trunk and limbs, but differs from that species in its smaller size, the smaller number of denticles on the chelae, and the relative proportions of the distal leg joints. There is a similar, but less marked, similarity between *N. molleri* and *N. subtile* Loman, 1923.

Nymphon novaehollandiae n. sp.

Figs. 7 A—I and 8 A—C

MATERIAL

2 males (1 is holotype), 2 females (1 is allotype), Station 37, "Thetis" Expedition, 2-2½ miles off Botany Bay, N.S.W., 90-93 metres, dredged. A.M. P.13597, P.13598, P.13599.

1 male, 2 miles east of Jibbon, at mouth of Port Hacking, N.S.W., trawled, 100 metres on mud, Jan. 17, 1945. Presented by C.S.I.R.O. Division of Fisheries. A.M. P.11528 (part).

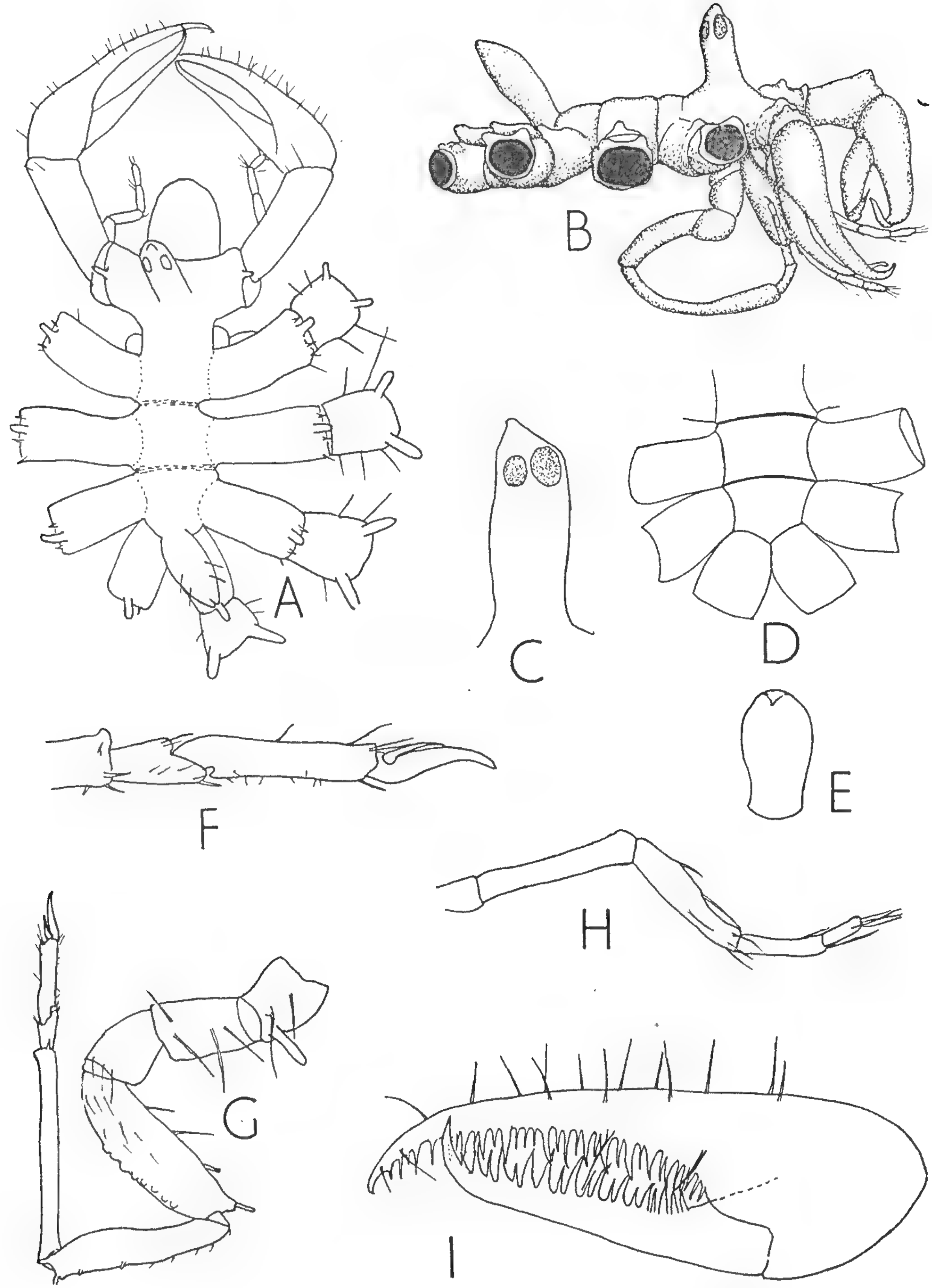

Fig. 7.—A-I, *Nymphon novaehollandiae.* A, dorsal view of trunk; B, lateral view of male paratype; C, ocular tubercle; D, ventral view of posterior trunk segments; E, proboscis; F, propodus; G, third leg; H, palp; I, chela.

1 female, off Botany Bay to Wata Mooli, N.S.W., 90 metres, from deck and nets of trawler "Thistle" (in port), coll. M. Ward, Jan. 19, 1925, A.M. P.7868.

1 female, off Botany Bay, N.S.W., 59-96 metres, taken from ground line of trawl on trawler "Karangai", coll. F. McNeill and A. Livingstone, Aug., 1921. A.M. P.5597 (part).

3 juveniles, 5 miles east of Port Hacking, N.S.W., 100 metres, presented by K. Sheard, C.S.I.R.O., Division of Fisheries, July, 24, 1943, A.M. P.11527 (part).

DESCRIPTION

Trunk robust, moderately compact, neck short, thick, chelifore bearing processes arranged at right angles to long axis of trunk, and provided with a tubercle near base of each chelifore. Segmentation lines between segments 1, 2, and 3 indistinct, no intersegmental line between segments 3 and 4; fourth segment almost suppressed, only the lateral processes visible in dorsal or ventral view (c.f. figs. 7 A and D). Lateral processes diverging, separated distally by their own width, much closer proximally, each armed distally with a low or moderately tall round-tipped tubercle, and sometimes a number of small pointed spines.

Ocular tubercle implanted between bases of chelifores and ovigers; tall, parallel-sided, rounded at tip, four eyes.

Proboscis short, cylindrical, distal half swollen, rounded at tip.

Abdomen set at an angle of up to 45°, fusiform with a few setae, reaching to end of fourth lateral processes, anus terminal.

Chelifores with one-jointed scape; scape with a few setae; chelae large, fingers longer than palm, tips crossing; immovable finger setose, longer than dactylus; teeth on both fingers slender; alternating one large tooth and one smaller one. Thirty-six denticles on immovable finger, nineteen on dactylus.

Palps five-jointed, second joint longest, third joint almost as long as second, fourth and fifth joints decreasing in size. Terminal joint with a few long setae; setae also present on joints three and four.

Oviger (male) basal joints short, fourth joint long, fifth joint longest, clavate and bowed, joints 6-10 decreasing in length. Oviger spines on joints 7-10 quite without denticulations, and conform to formula 3 : 3 : 2 : 3. Terminal claw pinnate along inner margin. Female oviger similar to that of male but fifth joint shorter, straight, and not clavate. Spine formula the same. Lengths of oviger joints (in mm.) are:—

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·225	0·405	0·33	0·675	1·15*	0·3	0·24	0·15	0·105	0·12
Female ..	0·3	0·375	0·345	0·735	0·84	0·42	0·225	0·18	0·15	0·18

* = measured as a chord.

Third Leg short and robust in proximal joints. Coxae short, thick, subequal; the first with two distal dorso-lateral round-tipped tubercles and a few setae. Femur stout with a number of small tubercles along ventral margin. First tibia a little shorter and more slender than femur; second tibia the longest joint. Tarsus almost half as long as propodus, with a few setae; propodus straight, with a few very weak setae on sole. Claw half as long as propodus, auxiliary claws half as long as main claw.

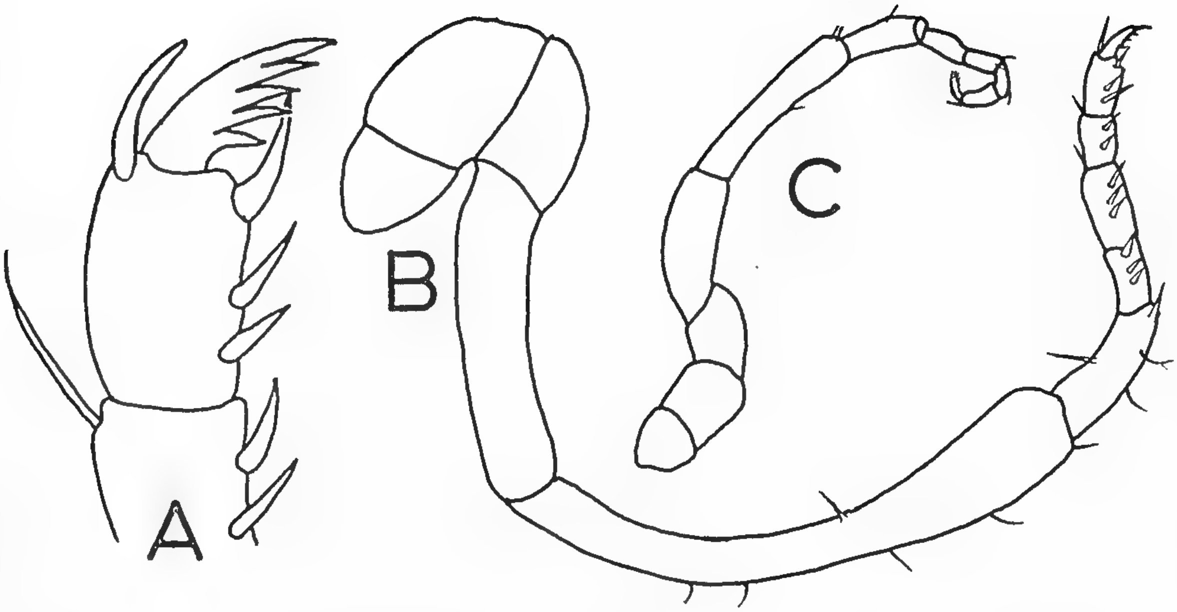

Fig. 8.—A-C, *Nymphon novaehollandiae*. A, terminal joints of male oviger; B, male oviger; C, female oviger.

Genital pores on distal part of ventral surface of second coxae of all legs in female where they are bounded by tumid lips. In males pores restricted to a similar position on third and fourth pairs of coxae only.

Measurements (in mm.): length of trunk (tip of celaphon—tip abdomen) 2·3, length of cephalon 0·92, width across second lateral processes 1·92, length chelifore scape 0·88, length proboscis 0·65, greatest width proboscis 0·5, length abdomen 0·65. Third leg: 1st coxa 0·57, 2nd coxa 0·6, 3rd coxa 0·525, femur 1·275, 1st tibia 1·125, 2nd tibia 1·35, tarsus 0·225, propodus 0·525, claw 0·3, auxiliary claw 0·165.

REMARKS

This species appears to be closely allied to two other Australian species, *N. singulare* Stock, 1954, and *N. immane* Stock, 1954. All three species have been taken in the same general region. The features shared by these species are (a) the long-fingered chelae, (b) the general structure of the oviger, i.e. the similarity of the joints, (c) the small number of denticulations on the oviger spines, (d) the small number of the spines themselves, (e) the presence of tubercles over the bases of the chelifores and on the distal ends of the lateral processes, and (f) the general structure of the propodus. *N. novaehollandiae* differs from these species, however, in the presence of non-denticulate oviger spines, the two tall tubercles on the distal dorso-lateral surfaces of the first coxae, and in the fingers of the chelae being of markedly unequal length.

Key to Australian species of **Nymphon**

1. Fourth trunk segment not visible ventrally (as in fig. 7D) ... 2

   Fourth trunk segment visible in ventral view (not as in fig. 7D) ... 3

2. Distance between chelifore bases greater than width of trunk ... *N. novaehollandiae* n. sp.

   Distance between chelifore bases less than width of trunk. ... *N. singulare* Stock.

3. Fingers of chelae bent almost at right angle to palm. *N. aequidigitatum* Haswell
   Fingers of chelae not bent at a marked angle to palm. 4
4. Second tibiae beset with setae longer than twice width of tibia. *N. bunyipi* n. sp.
   Second tibiae without long setae. 5
5. With tubercles over chelifore bases; neck short. *N. immane* Stock
   Without tubercles over chelifore bases; neck long. *N. molleri* n. sp.

Family **Callipallenidae** Hilton, 1942

Genus **Anoropallene** Stock, 1956

Anoropallene valida (Haswell)

Figs. 9, A—J

Nymphon validum Haswell, 1884: 1024-1025, pl. 54, figs. 6-9.
Parapallene valida Loman, 1908: 48.
Pallene (?) *valida* Flynn, 1920: 75-77, pl. XIX, figs. 7, 8.
Oropallene valida Marcus, 1940: 33. Stock, 1954: 29.
Pallene valida Stock, 1954: 31.
Anoropallene (?) *valida* Stock, 1956a: 46.

MATERIAL

2 larvigerous males and 1 female Nelsons Bay, Port Jackson, N.S.W. A.M. P.13600.

1 ovigerous male, Port Stephens, N.S.W. A.M. P.13601.

Despite the generic changes it has undergone, this species does not appear to have been recorded since Haswell's description. The female was previously unknown. Flynn's description of the male is satisfactory, but since he refers to Haswell's earlier description as a matter of convenience I provide a new description below and incorporate some new details.

DESCRIPTION

Trunk moderately robust, distinctly segmented, lateral processes separated from one another by about three-quarters of their own diameter. Cephalon expanded anteriorly and projects over proboscis. Neck well developed, short, but fairly wide. On cephalon above base of each chelifore is a distinct tubercle which bears two spines in the males but only one in the female. The only other spines or setae on trunk are the small spines found at the distal ends of lateral processes.

Ocular tubercle situated posterior to neck, and just anterior to origin of first pair of lateral processes. Tubercle low (about one-third of height of abdomen), rounded, or rather flattened, above. Eyes, four, well pigmented. On ocular tubercle are a pair of small, rounded eminences.

Abdomen short, appears vertical from above, but from the side is seen to be one and a half times as long as wide, and directed upward and backwards at an angle of about 70°.

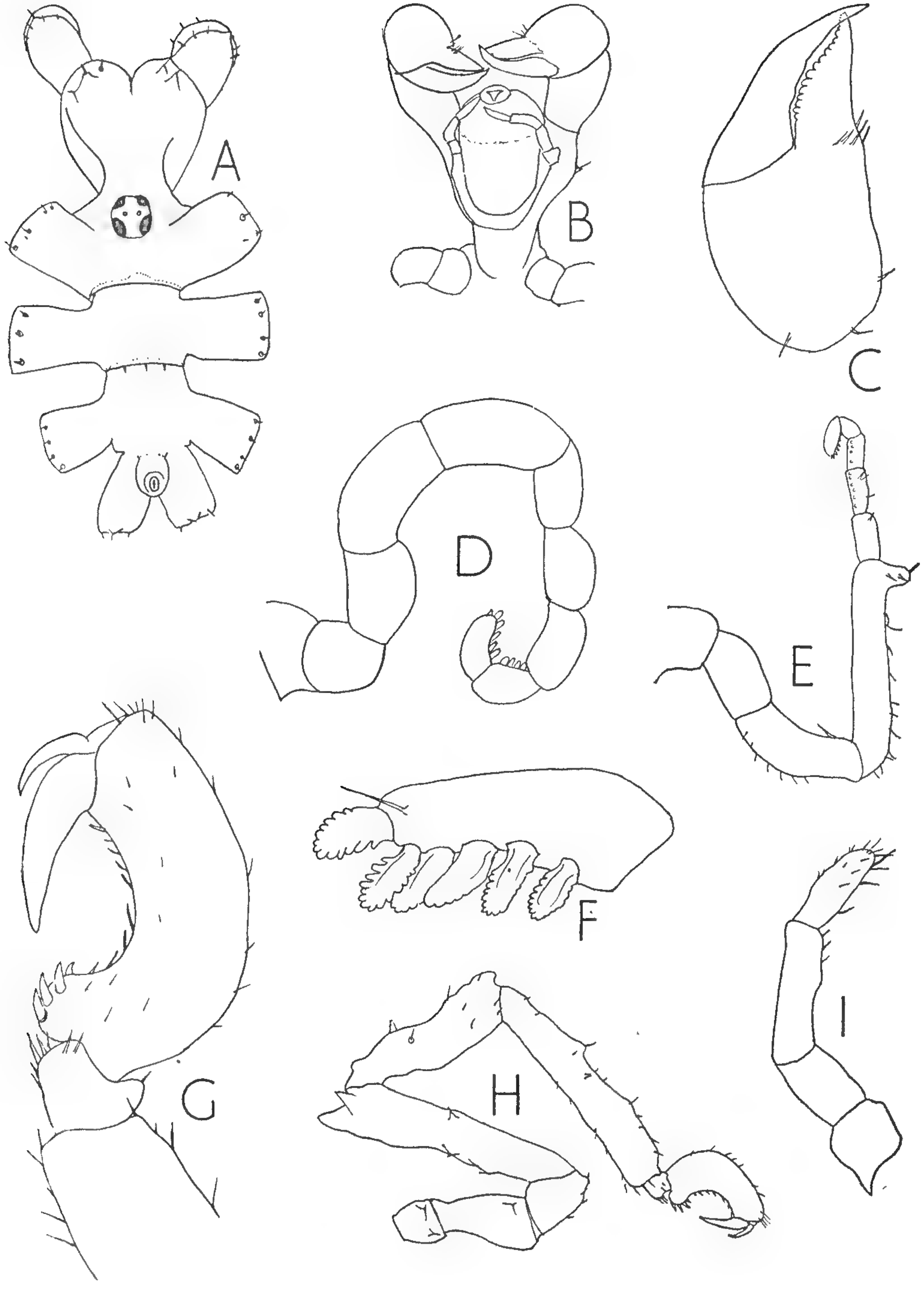

Fig. 9.—A-I, *Anoropallene valida*. A, dorsal view of trunk; B, ventral view of proboscis region of male; C, chela; D, female oviger; E, male oviger; F, tip of male oviger; G, propodus; H, third leg of male; I, male palp.

Proboscis short, about one and a half times as long as wide, directed obliquely downwards, basal part cylindrical, terminal third markedly triangular, especially in female, with a constriction about two-thirds of the way along. The tip is obtusely conical. I am unable to find the " wreath of very delicate bristles round the mouth " described by Flynn. Proboscis inserted into ventral surface of cephalon some distance behind anterior margin.

Chelifore scape of one joint, widest distally, and armed near the distal end with three spines, of which the most distal is the longest. Chela longer than scape, fingers shorter than palm; palm bulbous, ovoid. Inner margin of immovable finger finely crenulate, dactylus the longest finger, gently curved, margin untoothed but with several very slight callosities. Several spines near base of immovable finger, and a few short hairs on surface of palm.

Palps present in male only; four-jointed, extend beyond end of proboscis; third joint longest, first joint shortest. Flynn states that there " are scattered hairs on all the joints, but on the last there is a well marked ventral fringe of setae," but in the present material setae have been found only on the third and fourth joints.

Oviger 10-jointed in both sexes, without terminal claw; fifth joint longest in both sexes, but clearly so in the male where it is furnished with a large distal apophysis which is absent in the female. Denticulate spine formula for the four terminal joints of female oviger 4 : 6 : 4 : 6. No terminal claw; last spine very short. In the male oviger Haswell described five denticulate spines on the tenth joint, but his figure shows six. In the material before me two specimens have six spines, and one has seven on the last joint. Female oviger appears devoid of simple spines.

Third leg stout, armed with a number of blunt tubercles, each of which is armed with a simple spine. 1st coxa short, 2nd coxa twice as long as 1st coxa; femur with two large distal tubercles; equal in length to 2nd tibia. Propodus strongly curved, sole strongly concave, a moderate heel is present bearing four stout short spines, the more distal spines sparse and small. Terminal claw half as long as propodus, auxiliary claws less than half as long as terminal claw.

Genital apertures on second coxae of all legs in both sexes.

REMARKS

See under *Oropallene minor* n. sp.

Genus **Oropallene** Schimkewitsch, 1930

Oropallene minor n. sp.

Figs. 10 A—L

MATERIAL

3 males (1 ovigerous male is the holotype), 14 females (one is the allotype, the rest are paratypes). Off Cape Everard, Vict., 125-135 metres, trawled, coll. H. O. Fletcher, May, 1929. A.M. P.13602, P.13603, P.13604.

6 males, 11 females, 1 juvenile, off Twofold Bay, N.S.W., 81-90 metres, coll. Capt. K. Moller, trawler " Durraween ", Aug., 1929. A.M. P.13605.

2 males, 2 females, 1 juvenile, 5 miles off Green Cape, 81 metres, trawled, coll. Capt. K. Moller, May, 1930. A.M. P13606.

2 males, 2 females, trawled 2 miles east of Jibbon at mouth of Port Hacking, south of Port Jackson, N.S.W., 100 metres, on mud, July 17, 1943, pres. C.S.I.R.O., Division of Fisheries. A.M. P.11528.

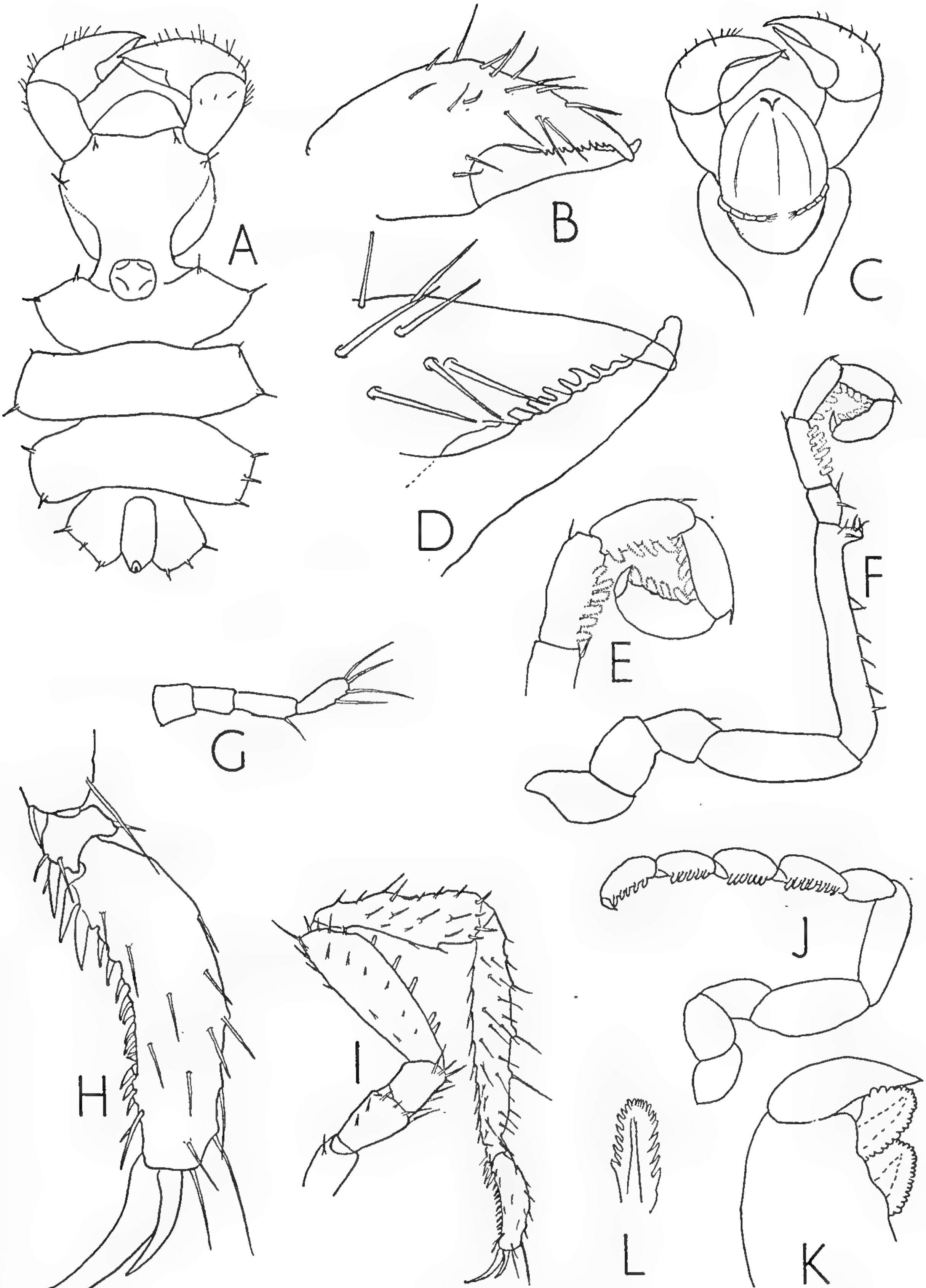

Fig. 10.—A-L, *Oropallene minor*. A, dorsal view of trunk; B, chela; C, ventral view of proboscis region to show rudimentary palps in male; D, tip of chela; E, tip of male oviger; F, male oviger; G, male palp; H, propodus; I, third leg; J, female oviger; K, tip of female oviger; L, oviger spine.

8 males, 5 females, station 57 "Thetis" Expedition, $3\frac{1}{2}$-4 miles off Wata Mooli near Botany Bay, N.S.W., 97-107 metres, dredged. A.M. P.13607.

7 males, 13 females, station 37 "Thetis" Expedition, 2-$2\frac{1}{2}$ miles off Botany Bay, N.S.W., 90-93 metres, dredged. A.M. P.13608.

6 males, 5 females, station 35 "Thetis" Expedition, $1\frac{1}{4}$-2 miles off Port Hacking, N.S.W., 39-69 metres, dredged. A.M. P.13609.

2 males from conglomerate boulder taken by trawler "Goonambee" about lat. 33° 44′ S. long. 151° 38′ E. (about 16-18 miles north-east of South Head, Port Jackson, N.S.W.). 135-144 metres; coll. C. W. Mulvey, May, 1924. A.M. P.13610.

Fragmentary material, south-east from Cape Everard, Vict., 125-134 metres F.I.S. "Endeavour", March 25, 1915. A.M. E.6172.

DESCRIPTION

Trunk compact, clearly segmented, dorsum smooth, colour (in alcohol) light straw, mid-brown, or dark brown; lateral processes touching proximally, but separated distally, and armed at ends with a few small setae. Cephalon produced anteriorly to form distinct neck; expanded beyond neck region to provide for the implantation of chelifores, proboscis and palps (the latter in males only). Near bases of chelifore scapes are two small spine-bearing tubercles.

Ocular tubercle situated in posterior half of cephalon in line with anterior margins of first lateral processes. Tubercle low, squat, rounded above, four eyes.

Proboscis short, directed ventrally and distally; basal half cylindrical, distal half triquetrous, tip rounded.

Abdomen short, wide at base, tapering towards tip. Abdomen set at an angle of 60-70° to dorsum.

Chelifore: scape one-jointed, stout, wider distally than proximally, with a few setae, chelae about same length as scape. Fingers almost as long as palm, crossing slightly at tips when closed, immovable finger with a few short irregular teeth, cutting edge of dactylus with a few low callosities in lieu of teeth; hand with a number of spines, especially on immovable finger.

Palps present in males only; four-jointed, very small. Basal joint shortest and widest, second joint a little longer and narrower; third and fourth joints longest and equal, with one and four setae respectively. Length of joints (in mm.) 0·056, 0·07, 0·1, 0·1. Palps arise from ventral part of cephalon alongside proboscis, and immediately below origins of chelifores.

Ovigers 10-jointed in both sexes. In male the fifth joint is long and bears a distal apophysis (a characteristic of this and allied genera); the fifth joint also bears a number of simple spines along its length. Denticulate spines present on joints 7-10 according to formula 6 : 4 : 4 : 4. Terminal claw present in both sexes. Female oviger similar to that of male, but smaller, fifth joint not conspicuously longer than fourth and lacking distal apophysis and simple spines; denticulate spine formula of female 7 : 6 : 5 : 5. Lengths of joints (in mm.):—

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·135	0·18	0·225	0·42	0·6	0·135	0·18	0·165	0·165	0·165
Female ..	0·103	0·15	0·165	0·315	0·33	0·135	0·18	0·165	0·165	0·165

Third leg moderately robust, very setose, coxae short; second coxa a little longer than others, femur stout, in male set with five peg-like cement glands on ventral surface, wider distally than proximally. First tibia equal to femur, second tibia the longest joint, widest in central region, with a row of regular setae along ventral margin. Tarsus short with one heavy spine and several setae on ventral margin. Propodus slightly arcuate, two large basal spines on heel, spines on the sole smaller. Claw strong, half as long as propodus; auxiliary claws well developed, more than half as long as main claw.

Measurements (in mm.): total length (tip proboscis to tip 4th lateral process) 1·6, length cephalon 0·6, width across second lateral processes 0·8, length abdomen 0·25, length proboscis 0·55, greatest width of proboscis 0·4, length chelifore scape 0·53. Third leg: 1st coxa 0·3, 2nd coxa 0·37, 3rd coxa 0·3, femur 1·05, 1st tibia 1·02, 2nd tibia 1·275, tarsus 0·075, propodus 0·525, claw 0·27, auxiliary claw 0·18.

Remarks

This species agrees in all respects with the characters of the genus *Oropallene* Schimk., and, like the type species, *O. dimorpha* (Hoek), it possesses auxiliary claws and a terminal oviger claw. When Stock (1956 a) erected the genus *Anoropallene,* he suggested that *O. valida* (Haswell) from Australia might be better included in that genus. The problem of placing of this Australian species is due to the fact that *O. valida* lacks a terminal oviger claw and so does not fit readily into *Oropallene,* but since it possesses auxiliary claws it does not fit comformably into *Anoropallene* either. I agree with Stock's view that within the Callipallenidae the oviger characters (such as the presence or absence of a terminal claw) are of greater taxonomic importance than the presence or absence of auxiliary claws. Because of this I incline towards Stock's view and provisionally assign *valida* to *Anoropallene* with the comment that this action is justified solely by the absence of the terminal oviger claw. The two species *A. valida* and *O. minor* are readily distinguished by the strongly curved propodus with auxiliary claws less than half as long as the propodus in *A. valida,* but in *O. minor* the propodus is only slightly curved, and the auxiliary claws are at least half as long as the main claw. Further, the lateral processes are more closely spaced and the chelae more setose in *O. minor* than in *A. valida.* *O. minor* differs from *O. dimorpha* (Hoek) in its much smaller size, the relative lengths of the coxal joint (the second coxa is relatively much shorter in *O. minor* than in *O. dimorpha*) in the shape and spination of the propodus, and in the fewer setae on the palps.

Genus **Callipallene** Flynn, 1929

Callipallene emaciata micrantha Stock.

Figs. 11 A—I

Callipallene emaciata micrantha Stock, 1954: 44-46, figs. 19 a-g, 20 a-b.

MATERIAL

2 males, 1 female, off Twofold Bay, N.S.W., 81-90 metres, coll. Capt. K. Moller, trawler "Durraween", trawled Aug., 1929. A.M. P.13611.

1 male, 5 miles off Green Cape, N.S.W., 90 metres, trawled, coll. K. Moller, May, 1930. A.M. P.13612.

5 males, 3 females, about 7 miles off Twofold Bay, N.S.W., trawled 81 metres. coll. K. Moller, trawler "Durraween", Oct., 1929. A.M. P.13613.

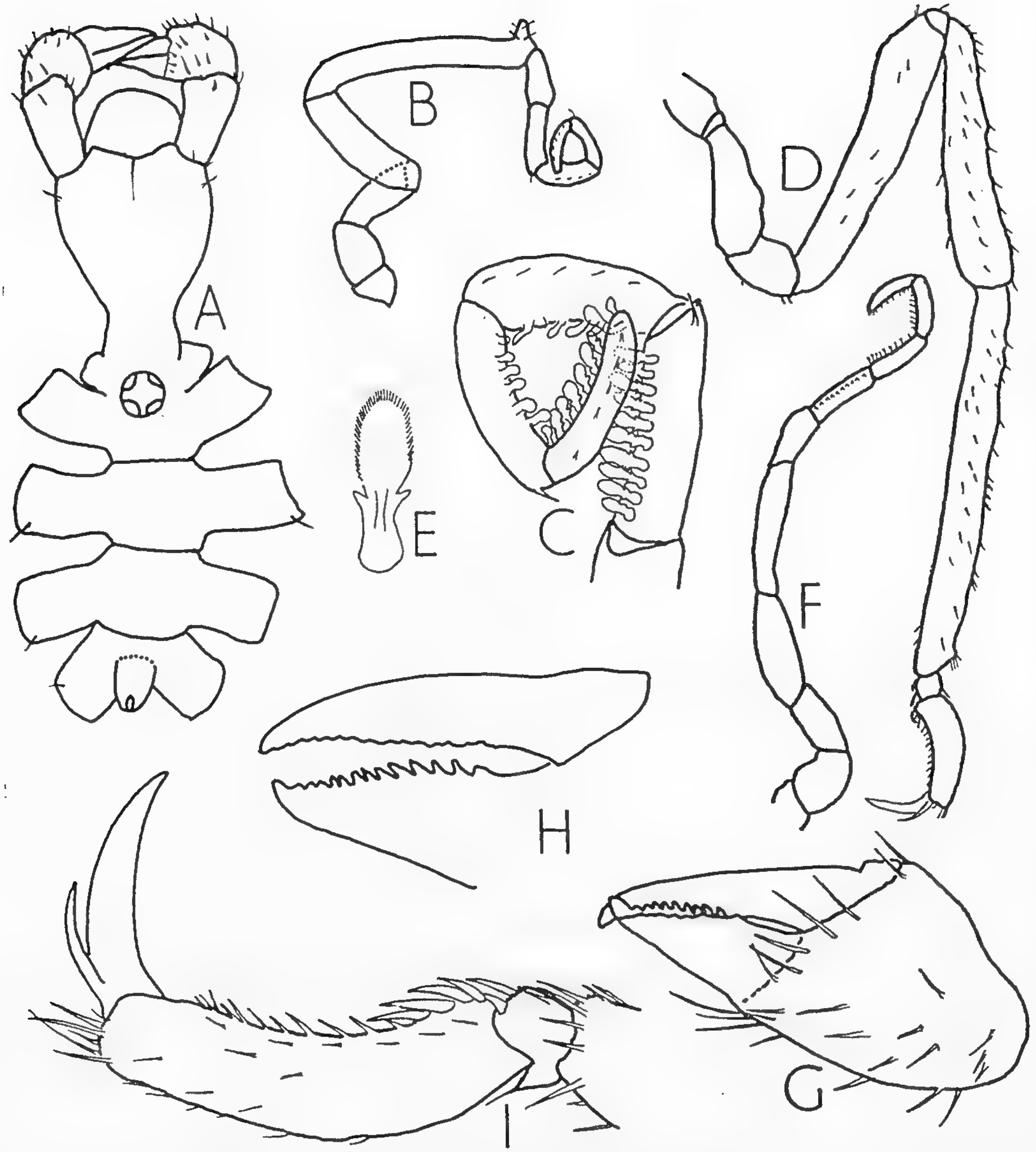

Fig. 11.—A-I, *Callipallene emaciata micrantha.* A, dorsal view of male trunk; B, male oviger; C, tip of male oviger; D, third leg; E, oviger spine; F, female oviger; G, chela; H, detail of chela fingers; I, propodus.

4 females, west-south-west from Gabo Island, N.S.W., trawled 126 metres, coll. K. Moller, trawler "Durraween", Dec. 1929. A.M. P.13614.

12 females, 13 males, 14 miles off Bateman's Bay, N.S.W., trawled 135 metres, coll. Capt. K. Moller, trawler "Durraween", A.M. P.13615.

4 males, 2 females, off Cape Everard, Vict., 126-135 metres, coll. H. O. Fletcher, trawled, May, 1929. A.M. P.13616.

1 male, 1 female, off Gabo Island, N.S.W., "Endeavour" Expedition, A.M. E.4649.

REMARKS

The subspecies of the *Callipallene emaciata* and *C. brevirostris* groups are not easily distinguished because of the variation present in a number of characters. I am, however, fairly confident that the material listed above is all referable to this subspecies. Much of this material differs from Stock's figures and description, particularly in the spination of the lateral processes and the cephalon near the chelifore bases. The spination of the chelifores is also somewhat variable. The number of spines near the chelifore bases varies from 1-4 in each group, and the number on the lateral processes is also variable, but the processes of trunk segments 2-4 always appear to have at least one spine each. The male ovigers vary greatly in the development of the simple spines of the fifth joint, and in the arrangement of the compound spines on the terminal joints. The following arrangements have been found: 9 : 8 : 7 : 9, 10 : 8 : 7 : 10, 11 : 9 : 11 : 10 and 12 : 10 : 10 : 11.

The female is new to science, and is very similar to the male except that in some specimens the inner margin of the distal part of the chelifore scape is armed with more spines than shown in Stock's figure (of the male). As is to be expected, the oviger differs in having a shorter fifth joint which is quite without any distal apophysis. Oviger spine formulae of the females examined: 10 : 10 : 9 : 9, 10 : 9 : 9 : 11, 10 : 9 : 9 : 10.

The distribution of this species is still restricted to the area between Cape Everard in the south and Batemans Bay in the north, and the bathymetric range extends from about 80 metres to 135 metres.

Callipallene sp.

Figs. 12 A—H

MATERIAL

1 male, 1 juvenile, about 7 miles off Twofold Bay, N.S.W., trawled, 81 metres, coll. Capt. K. Moller, trawler "Durraween", Aug., 1929. A.M. P.13617.

DESCRIPTION

Trunk moderately compact, neck region well developed, crop large with slight median fissure anteriorly, cephalon slightly longer than remainder of trunk. Lateral processes separated by about their own width, quite unadorned.

Ocular tubercle tall for the genus, acutely conical above (fig. 12 F), eyes well pigmented, four.

Proboscis short, when viewed ventrally is sharply angled at the distal lateral extremities, in dorsal view appears rounded distally and bears a few short setae near tip.

Abdomen short, cylindrical, almost erect, anus terminal.

Chelifore scape one-jointed, with a few spines on inner margin and a circlet of spines at articulation with chela. Chela palm strongly inflated, palm longer than fingers which are set at a slight angle to it. Dactylus with 14 low rounded teeth; margin of immovable finger entire. Setae most abundant at base of dactylus.

Palps absent.

Oviger (male) 10-jointed, typical of genus with a long fifth joint bearing a distal apophysis and a number of short simple spines. Compound oviger spines

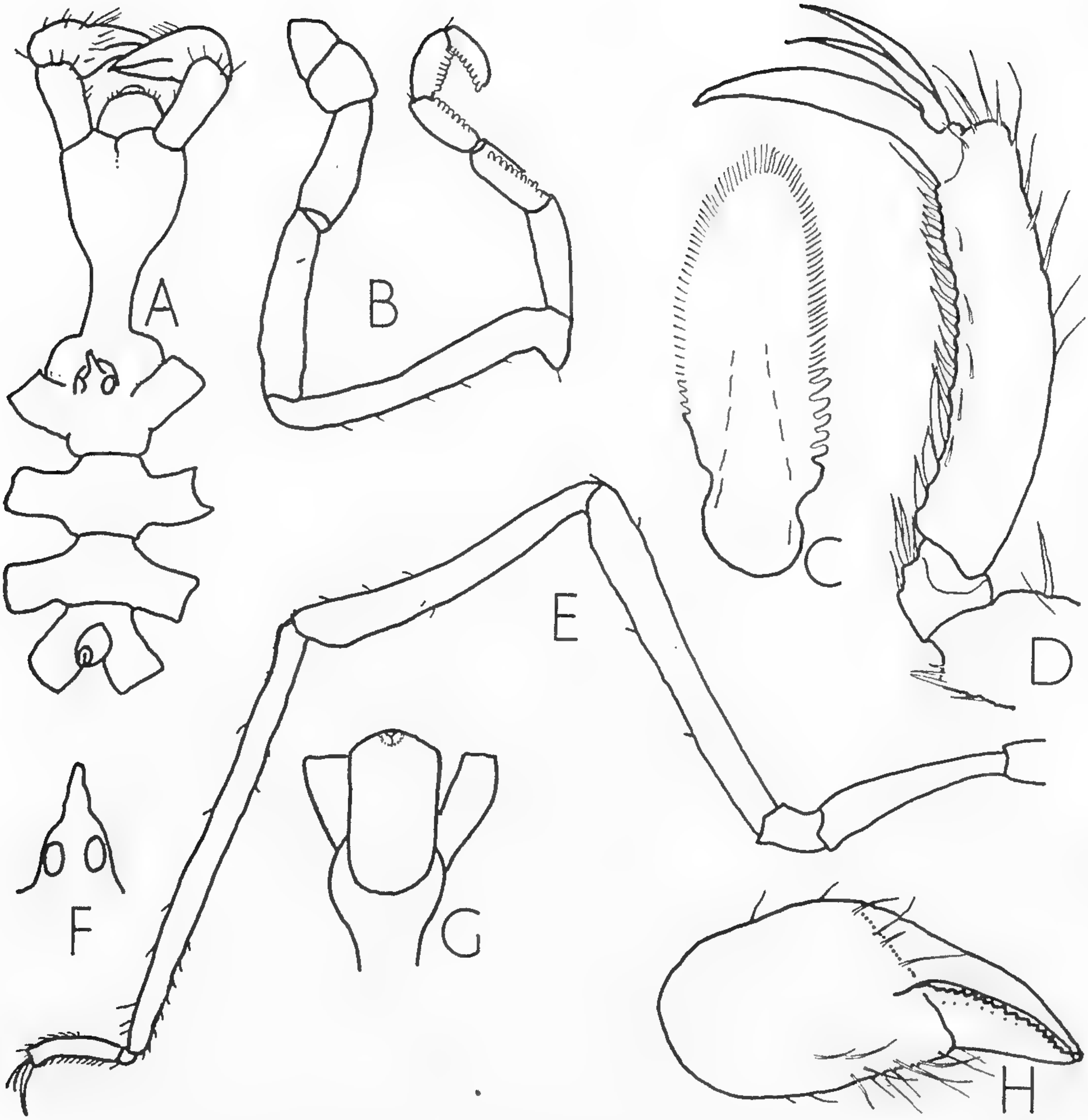

Fig. 12.—A-H, *Callipallene* sp. (all figs. of male). A, dorsal view of trunk; B, male oviger; C, oviger spine; D, propodus; E, third leg; F, lateral view of ocular tubercle; G, ventral view of proboscis; H, chela.

present on joints 6-10 according to formula 10 : 9 : 8 : 9. Compound oviger spines with rather more elongate blades than usual (fig. 12C). Length of joints 1—0·18, 2—0·2, 3—0·42, 4—0·62, 5—0·95, 6—0·38, 7—0·275, 8—0·23, 9—0·24, 10—0·21.

Third leg slender, without any outstanding characters (see fig. 12E). Propodus of *brevirostris* type, i.e., almost straight sole and long auxiliary claws.

Measurements (in mm.): total length (anterior margin of cephalon to tip fourth lateral process) 2·33, length cephalon 1·27, width across second lateral processes 0·87, length chelifore scape 0·5, length abdomen 0·33, length proboscis 0·6, greatest width of proboscis 0·4. Third leg: 1st coxa 0·27, 2nd coxa 1·18, 3rd coxa 0·41, femur 2·32, 1st tibia 2·03, 2nd tibia 2·78, tarsus 0·12, propodus 0·58, claw 0·32, auxiliary claw 0·23.

REMARKS

In view of the paucity of material and the variation which exists in other Australasian species in this genus I refrain from naming this form. The fact that it was taken with other specimens of *C. emaciata micrantha*, which is itself a variable subspecies, throws some doubt on the status of this form which appears to differ from the other Australian forms in the great height of the ocular tubercle, the well developed neck region, and the presence of teeth on the dactylus only. Taken in combination these characters may indicate a new species.

Genus **Parapallene** Carpenter, 1892

Parapallene australiensis (Hoek)

Pallene australiensis Hoek 1881: 76-78, pl. XI figs. 1-7 (in part). ——Haswell 1884: 1022.

Parapallene australiensis Carpenter 1892: 553. ——Loman 1908: 48. ——Calman 1937: 530-532 (redescr. of types). ——Stock, 1954: 50, fig. 24 d-e.

MATERIAL

1 male, 1 female, vicinity Sow and Pigs Shoal, Port Jackson, N.S.W., about 8 metres, coll. F. A. McNeill and M. Ward, Nov., 1929. A.M. P.13618.

4 males, 3 females, same data as above, Oct. 18, 1927. A.M. P.13619.

1 female, reef on shore between tidemarks, Kurnell, Botany Bay, N.S.W., coll. M. Ward, Jan. 22, 1928. A.M. P.9060.

3 females west-south-west from Gabo Island, N.S.W., 130 metres, coll. Capt. K. Moller, "Durraween", trawled Dec., 1929. A.M. P.13620.

1 male off Green Cape, N.S.W., coll. Capt. K. Moller, trawled July, 1926. A.M. P.13621.

1 male, trawled 3-4 miles off Eden, N.S.W., 46-56 metres, trawler "Goonambee", coll. H. O. Fletcher and A. Livingstone. A.M. P.13622.

1 male off Cape Everard, Vic., 130-140 metres, trawled, coll. H. O. Fletcher, May, 1929. A.M. P.13623.

1 female, Jervis Bay, N.S.W., in prawn trawl, Pres. C.S.I.R.O. Div. of Fisheries, Feb. 12, 1952. A.M. P.13624.

1 male, 1 female off Twofold Bay, N.S.W., 83-93 metres, coll. Capt. K. Moller, "Durraween", trawled Aug. 1929. A.M. P.13625.

1 male, 5 miles off Green Cape, N.S.W., 83 metres, trawled, coll. K. Moller, May, 1930. A.M. P.13626.

REMARKS

The present collection of this species consisting of ten males and eight females allows one to draw up the characters of this species with more confidence than was possible on the three specimens known previously. The present material differs slightly from the descriptions of Hoek (1881) and Calman (1937). I can find no sign of the cuticular fold in front of the ocular tubercle mentioned by Calman (=the "true articulation" of Hoek which divides the cephalic from the thoracic part). The ocular tubercle is situated over the region of the anterior half of the first lateral

processes and the posterior half of the bases of the ovigers. The ocular tubercle is directed slightly backwards, and may bear either one or two minute apical tubercles. The eyes bulge slightly. Situated laterally on the upper half of the tubercle is a pair of small papillae. Hoek notes that in his specimens the abdomen is "directed a little upwards", but in all the specimens before me the abdomen is practically vertical.

A feature of the proboscis not mentioned by earlier authors is the pair of groups of setae placed dorso-laterally at the distal extremity of the inflated portion of the proboscis. In both sexes, each group is composed of five or six setae.

Calman states that the compound oviger spines of the males are present in the types according to the formula 8 : 6 : 5 : 5; this feature is apparently variable, as in three males examined the formulae were 8 : 8 : 7 : 8, 9 : 8 : 7 : 7, and 8 : 9 : 7 : 8.

The female oviger differs from the male in that the basal joints are not as robust, the fifth joint is straight (strongly curved in male), lacks the terminal apophysis and the sixth joint is not furnished with setae as in the male. The ovigers of the two sexes also differ in the relative lengths of the joints as shown below. Compound oviger spines in three females examined had the formulae 11 : 11 : 8 : 9 (two specimens) and 12 : 9 : 8 : 8. Lengths of oviger joints (in mm.):

Joint ..	2	3	4	5	6	7	8	9	10
Male	0·39	0·66	1·42	1·93*	1·36	0·46	0·39	0·33	0·33
Female	0·31	0·55	1·39	1·22	0·89	0·55	0·45	0·41	0·39

*Measured as a chord.

The legs of the two sexes differ as noted by Stock (1954) in that the females lack the prominent coxal spines of the males. The spination of the propodus also differs very slightly.

The genital pores of both sexes are found on the second coxae of all legs. The female pores are much larger than the male ones.

It seems likely that the female of this species is the form Milne Edwards described as *Pallene chiragra* from "Jervis Bay, New Holland". Hoek appears to have suspected this when, in 1881, he noted the prominent coxal spines of male *P. australiensis* and contrasted them with the description of *P. chiragra*. Dr. Louis Fage informs me (*in litt.*) that the type specimen of *P. chiragra* is not in the Paris Museum, and that it has probably been lost with much more of Milne Edwards's material. As the description of *P. chiragra* is brief, unillustrated, and no type material is available, I regard it as a *species inquirenda*, and prefer to use the name *P. australiensis* for the material which is before me and which agrees with the types in the British Museum.

Parapallene haddoni Carpenter

Figs. 13 A—J

Parapallene haddoni Carpenter, 1892: 553-555, pl. 22, figs. 1-6. ——Loman, 1908: 44.

MATERIAL

1 damaged and 1 moulting juvenile, Murray Island, Torres Strait, coll. C. Hedley and A. R. McCulloch, Aug., Oct., 1907. A.M. P.13627.

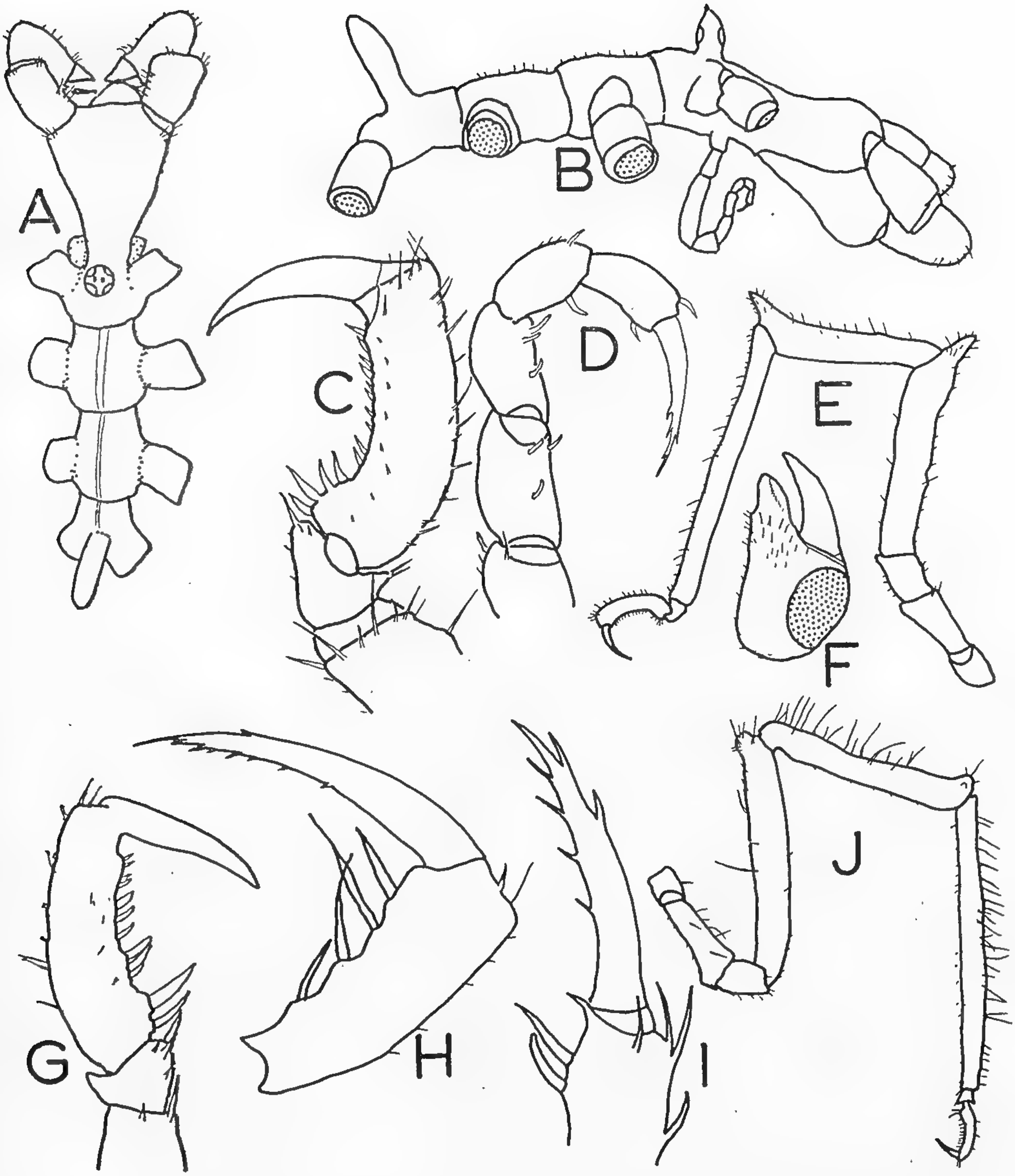

Fig. 13.—A-J, *Parapallene haddoni* (figs. A-F of an immature specimen from Murray Island). A, dorsal view of trunk; B, lateral view; C, propodus; D, terminal joints of oviger; E, third leg; F, chela; G-H, propodus and terminal oviger joints of a female from Holothuria Bank; I-J, terminal oviger claw and third leg of female co-type.

1 female, Holothuria Bank, Northern Australia, Coll. H.M.S. "Penguin" and presented to the British Museum by the Admiralty, 1893.

REMARKS

I have examined the syntypes of this species which are now in the British Museum (Nat. Hist.) and find they consist of one juvenile and one female, not male and female as stated by Carpenter. There are a number of differences between them. The female has strongly spinose legs (fig. 13J) and resembles the present

material more closely than does Carpenter's larva. The female from Holothuria Bank, apart from its larger size, is more like the juveniles from Murray Island than is Carpenter's female. The problem of whether more than one species is represented cannot be decided on the material available. In the meantime, I regard the material as representing a single species.

Because Carpenter's figures are inadequate by modern standards, I have provided new ones based on the material available.

Parapallene famelica Flynn

Figs. 14 A—G

Parapallene famelica Flynn, 1929: 258-260, figs. 6-9.

MATERIAL

1 female from off Port Philip. (Specimen in collection of the British Museum (Nat. Hist.).)

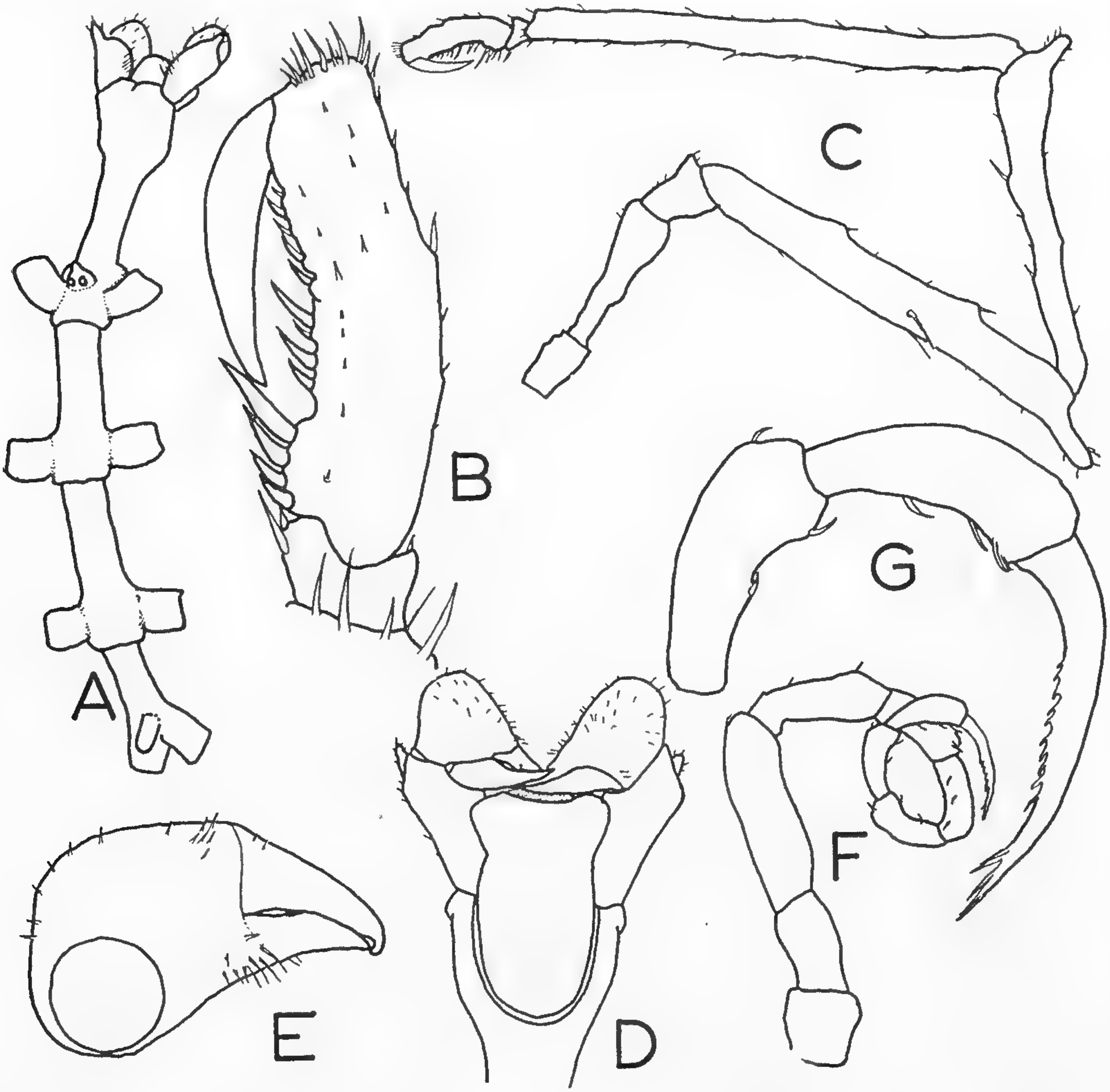

Fig. 14.—A-G, *Parapallene famelica* female. A, dorsal view of trunk; B, propodus; C, third leg D, ventral view of proboscis region; E, chela; F, oviger; G, tip of oviger.

REMARKS

Although this specimen differs in some respects from Flynn's description, which was based on a single male, I believe that it is referable to this species. The differences may be sexual in character. The chief differences are in the presence of pronounced dorso-terminal processes on the distal ends of the single-jointed chelifore scape, and the abundance of spines on the inner edges of the scapes. The proboscis is much more truncate than Flynn's figure indicates. The spination of the legs is almost entirely omitted in his figure, and the figure of the propodus is wholly inadequate. The terminal oviger claw also differs. The almost complete fusion of the third and fourth oviger joints in both specimens point to their being the same species. Because Flynn's figures are inadequate by modern standards, new figures are provided.

Flynn suggested that this species is very closely allied to *P. nierstraszi* Loman, but the similarities seem to have been over-emphasized as the two species differ radically in the form of the trunk, legs, propodus, oviger, and in the shape of the proboscis.

Measurements (in mm.): total length (tip cephalon to tip fourth lateral process) 12 mm., width across second lateral processes 2·66, length cephalon 4·86, length chelifore scape 1·07, length proboscis 1·87, greatest width proboscis 1·13, third leg; 1st coxa 1·2, 2nd coxa 2·53, 3rd coxa 1·2, femur 8·0, 1st tibia 6·0, 2nd tibia 8·0, tarsus 0·4, propodus 2·0, claw 1·07, oviger joints: 1—0·44, 2—0·57, 3 and 4—1·09, 5—0·775, 6—0·545, 7—0·47, 8—0·45, 9—0·39, 10—0·417, claw 0·57.

Parapallene obtusirostris n. sp.

Figs. 15 A—I

MATERIAL

1 female (holotype), dredged off Portsea, Port Phillip, Victoria. Coll. C. Gabriel, May 7, 1914, A.M. P.3958.

DESCRIPTION

Colour (in alcohol) brown, with an irregular median stripe of pale straw colour.

Trunk robust, segmented, lateral processes separated by about half their diameter throughout their length. Integument ornamented by a few simple spines: three on dorsum, two or three at ends of lateral processes, and a few on abdomen. Neck region of cephalon strongly developed; just anterior to first pair of lateral processes and ocular tubercle arise a pair of cervical processes to which the ovigers are articulated. Distal part of cephalon much expanded to accommodate origins of proboscis and chelifore scapes. A slight cleft present in dorsal mid-line of cephalon.

Ocular tubercle implanted with anterior margin in line with anterior edge of first lateral processes; a little higher than diameter of tubercle at base, parallel sided, tip a rounded cone; four large eyes.

Proboscis inserted on ventral side of anterior part of cephalon, which forms a low collar about the base. Basal two-thirds cylindrical with a constriction at two-thirds of total length, after which proboscis expands, especially in the ventro-lateral parts to make anterior margin of proboscis appear as a straight line in ventral view. Distal third markedly triquetrous, and bears four fine setae in a dorso-lateral position. On ventral side of each of anterior corners of proboscis is found a single stout seta.

Abdomen cylindrical, truncated, set at an angle of 45°, with a few setae at tip, anus terminal.

Chelifores: scape one-jointed, short, thick, with a single stout spine on outer dorso-lateral extremity; inner margin with a number of finer setae. Hand of chela strongly inflated, rather spherical, with numerous short setae. Fingers shorter than hand, cutting edges of both fingers curved, crossing slightly at tips, dactylus slightly longer than immovable finger. Rows of setae surround bases of fingers.

Palps lacking.

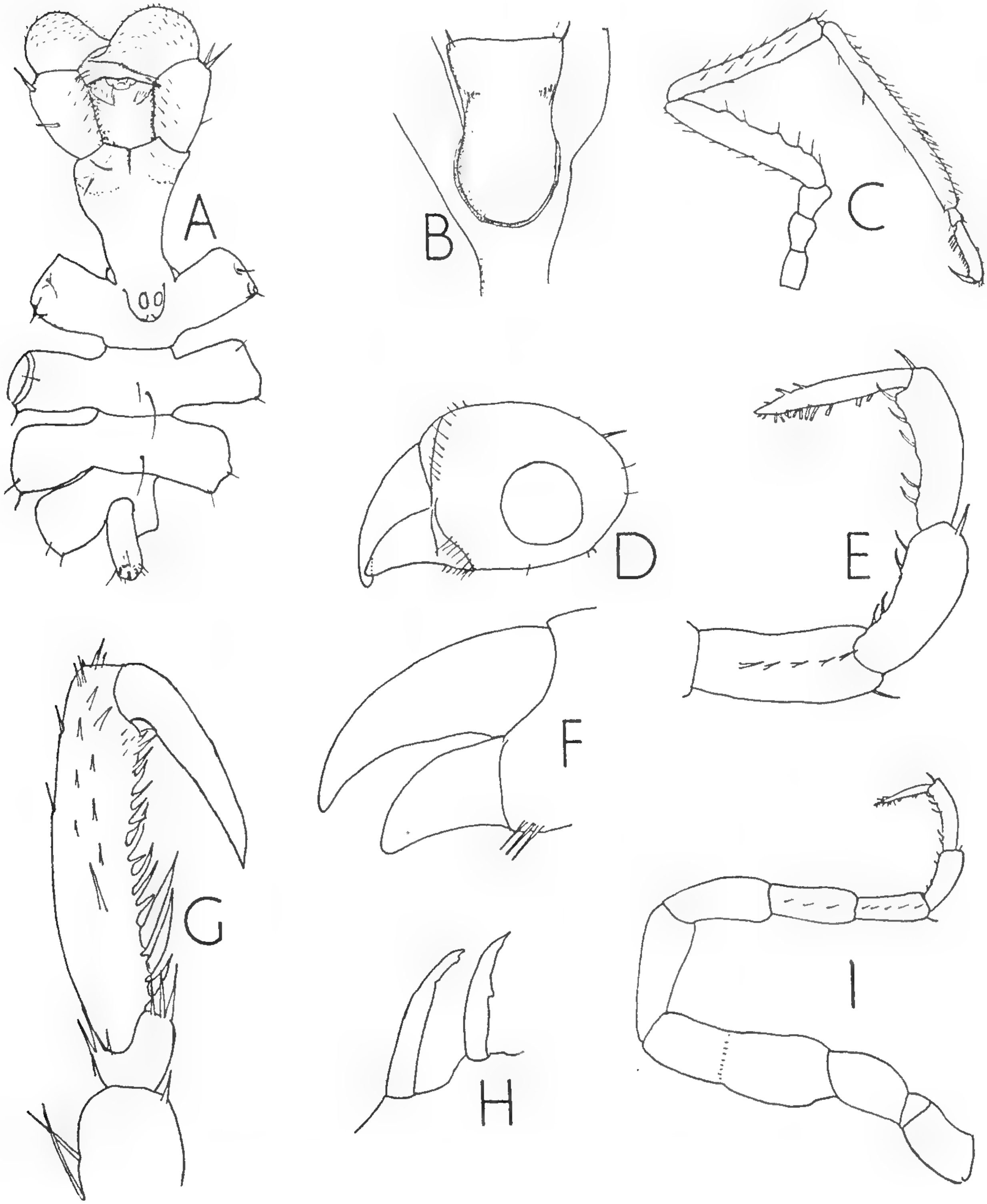

Fig. 15.—A-I, *Parapallene obtusirostris*. (All figs. of female holotype.) A, dorsal view of trunk; B, ventral view of proboscis; C, third leg; D, chela; E, tip of oviger; F, fingers of chela; G, propodus; H, proximal spines of tenth oviger joint; I, oviger.

Ovigers ten-jointed, third and fourth joints fused, together making the longest "joint"; fifth joint next longest, succeeding joints decreasing in length. Joints 7-10 with simple oviger spines according to formula 3 : 6 : 5 : 6. Oviger spines simple with very slight irregular denticulations near tip. Terminal claw long, almost straight, with denticulations on both edges, mostly distally, and more on inner edge.

Third leg moderately robust, all joints with some setae, second coxa longest coxal joint, but not equal to first and third combined. Femur and first tibia subequal in length, but femur more robust, and with a series of spine-bearing tubercles along ventral margin. Second tibia longest joint, both tibiae clothed with long setae whose length is equal to width of joint. Tarsus short; propodus moderately robust. Three proximal basal spines strong, more distal ones decreasing in size. Terminal claw strong, more than half as long as propodus; auxiliary claws lacking.

Measurements (in mm.): total length (tip of proboscis to tip of abdomen) approximately 3·75, length cephalon 1·6, length of proboscis 1·0, greatest diameter of proboscis 0·62, width across second lateral processes 1·5, length chelifore scape 0·75, length of abdomen 0·8. Third leg: 1st coxa 1·1, 2nd coxa 1·6, 3rd coxa 1·3, femur 5·5, 1st tibia 5·33, 2nd tibia 7·0, tarsus 0·4, propodus 1·9, claw 1·1.

REMARKS

Parapallene obtusirostris differs from all other species in the genus in the possession of a terminal oviger claw which is denticulate on both edges and a square-ended proboscis. The spine on each of the anterior ventral corners of the proboscis also appears to be unique.

Key to Australian species of **Parapallene**

1. Auxiliary claws present — 2
   Auxiliary claws absent — 3
2. Terminal oviger claw not denticulate; oviger spines broad as in *Callipallene* spp.; fingers of chelae denticulate — *P.* (?) *aculeata* Stock
   Terminal oviger claw denticulate; oviger spines not as in *Callipallene;* fingers of chelae not denticulate — *P. challengeri* Calman
3. Lateral processes separated by at least their own width — 4
   Lateral processes separated by less than their own width — *P. obtusirostris* n. sp.
4. Lateral processes separated by more than three times their own width — *P. famelica* Flynn
   Lateral processes separated by less than three times their own width — 5
5. Distal ends of femur and first tibia with conspicuous processes and propodus with a moderate heel — *P. haddoni* Carpenter
   No processes on distal ends of femora or tibiae; no heel on propodus — *P. australiensis* (Hoek)

Genus **Pseudopallene** Wilson, 1878

Pseudopallene ambigua Stock.

Figs. 16 A—F

Pseudopallene ambigua Stock, 1956 b: 40-42, fig. 5.

MATERIAL

2 females, trawled 3-4 miles off Eden, N.S.W., 45-54 metres, trawler "Goonambee". Coll. A. Livingstone and H. O. Fletcher. A.M. P.13628.

2 males, 4 females, 6 juveniles, Port Arthur, Tasmania, coll. E. Mawle. A.M. P.13629.

1 female, trawled west-south-west from Gabo Island, N.S.W., 126 metres, coll. Capt. K. Moller, trawler "Durraween", Dec., 1929. A.M. P.13630.

1 ovigerous male off Nobby's Head, Newcastle, N.S.W., Sept. 1, 1911. A.M. P.4902.

1 immature, between Long Reef and Narrabeen Head, north of Port Jackson, N.S.W., about 5 miles off shore, brought up on small anchor from about 95 metres, coll. W. Steltzer, A.M. P.10471.

REMARKS

In 1956 Stock described *P. ambigua* from Bass Strait, and at this time he noted that he had only described it as new after some hesitation. His new species differed from *P. pachycheira* Haswell mainly in size, *P. ambigua* being much larger. Stock suggested that the unique specimen of Haswell's species may not have been fully adult. Mr. F. A. McNeill, of the Australian Museum, has examined the type of this species for me and reports that the genital apertures are present. I have examined all the mature males before me to determine whether one or more species is involved. No differences apart from size have been discovered in the trunk. The third legs

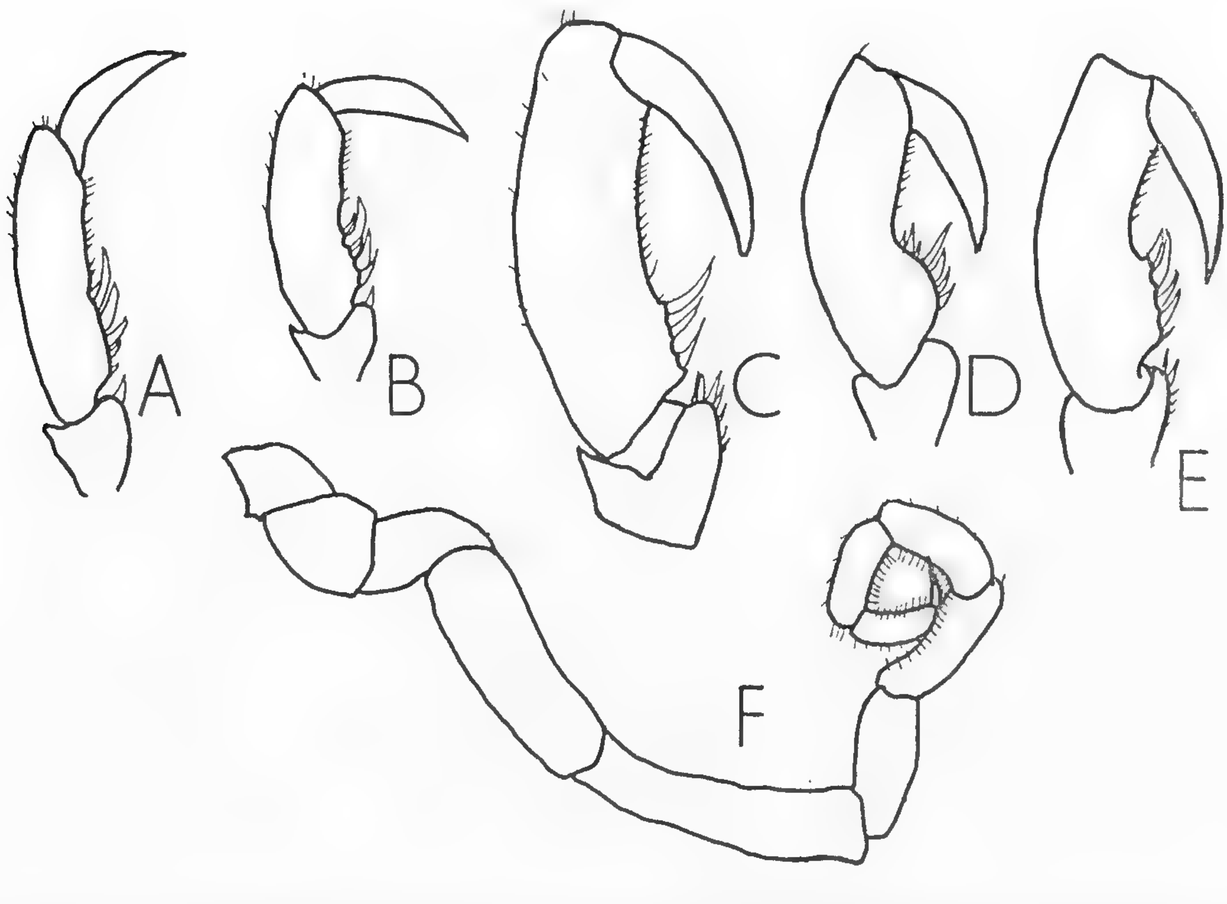

Fig. 16.—A-F, *Pseudopallene ambigua*. A-E, propodes of third legs of males showing the variation encountered (all at the same magnification); A-C, from ovigerous males; D and E, from non-ovigerous males; A and D, off Eden, N.S.W.; B and E, Port Arthur, Tasmania; C, Nobby's Head, N.S.W.; F, female oviger.

have been measured and the number of denticulate oviger spines counted. The results are set out in the table below:

Source	Spine Formula	Coxa 1	Coxa 2	Coxa 3	Femur	Tibia 1	Tibia 2	Tarsus	Propodus	Claw
Off Eden	18: 12: 10: 10	0·75	2·5	1·05	4·6	4·4	5·9	0·33	1·15	0·6
Off Eden	11: 6: 6: 6	0·77	2·2	1·0	3·68	3·0	3·68	0·33	1·22	0·74
Nobby's Head ..	14: 12: 11: 11	0·8	2·75	1·3	5·75	5·25	6·8	0·44	1·65	0·85
Pt. Arthur ..	25 :18: 15: 15	0·85	2·85	1·35	4·95	4·35	5·34	0·33	1·3	0·77
Pt. Arthur ..	14: 11: 9: 10	0·7	1·62	0·66	3·12	2·68	2·45	0·26	0·9	0·66
Type *ambigua* ..	15: 9: 10: 10	0·93	2·0	0·8	4·7	4·5	5·0	0·2	1·3	0·8
Type *pachycheira* ..	*5 or 6: 5: 4: 4	0·45	1·09	0·44	2·05	1·82	—	0·93		0·51

* Mr. McNeill states that because of a bubble in the balsam in which the specimen is mounted, he is unable to be certain of the number of spines on the seventh oviger joint.

As shown in Fig. 16, the form of the propodus is rather variable. One immature specimen from between Long Reef and Narrabeen Head is intermediate in size between the two types. A note with this specimen records that " in life, body was spotted black and yellow; limbs dark red, yellow at joints—the yellow edged with black ". None of this colour persists in the preserved specimen.

Up to the present no two males (or females) of this group have been found to be exactly alike. Rather than give nomenclatorial recognition to each specimen, I propose, in the meantime, to treat all the material as belonging to *P. ambigua* in full awareness of the fact that further material may make this position untenable.

None of the present material shows signs of the regular annular constrictions of the long joints as described by Flynn. The palms of the chelae of the present material all resemble Stock's figure rather than Haswell's, though the fingers are practically identical in both. Stock states that in his specimen the terminal oviger claw is untoothed, whereas all the specimens before me have toothed oviger claws as described by Flynn, but not as figured by Haswell. The oviger spines resemble those of Stock's figure, and are quite unlike Haswell's figure. Unfortunately, I have not been able to examine either of the types personally.

Pseudopallene dubia n. sp.

Figs. 17 A—H, 18 A—B

MATERIAL

5 females (1 is holotype), Port Arthur, Tasmania, in kelp weed. Coll. Barnett, A.M. P.13631, P.13632.

2 females, Port Arthur, Tasmania. Coll. E. Mawle. A.M. P.13633.

DESCRIPTION

Trunk compact, almost circular in outline, smooth, without ornament; lateral processes touching or almost touching. Cephalon greatly expanded anteriorly over bases of chelifores and proboscis, with or without a slight cleft at anterior margin.

Ocular tubercle low, rounded above, placed anterior to first lateral processes. Four eyes. A pair of latero-apical papillae present.

Proboscis directed ventrally; of two regions, a rather barrel-shaped basal part and narrow tapering distal region. The distal portion is fused, i.e., not composed of three separate or distinguishable lips.

Abdomen stout, fusiform, directed slightly downwards, and reaching almost to end of first coxa.

Chelifore scape one-jointed, almost as long as proboscis; chela short, squarish, palm strong, but rather variable in shape and spination. Fingers short and weak

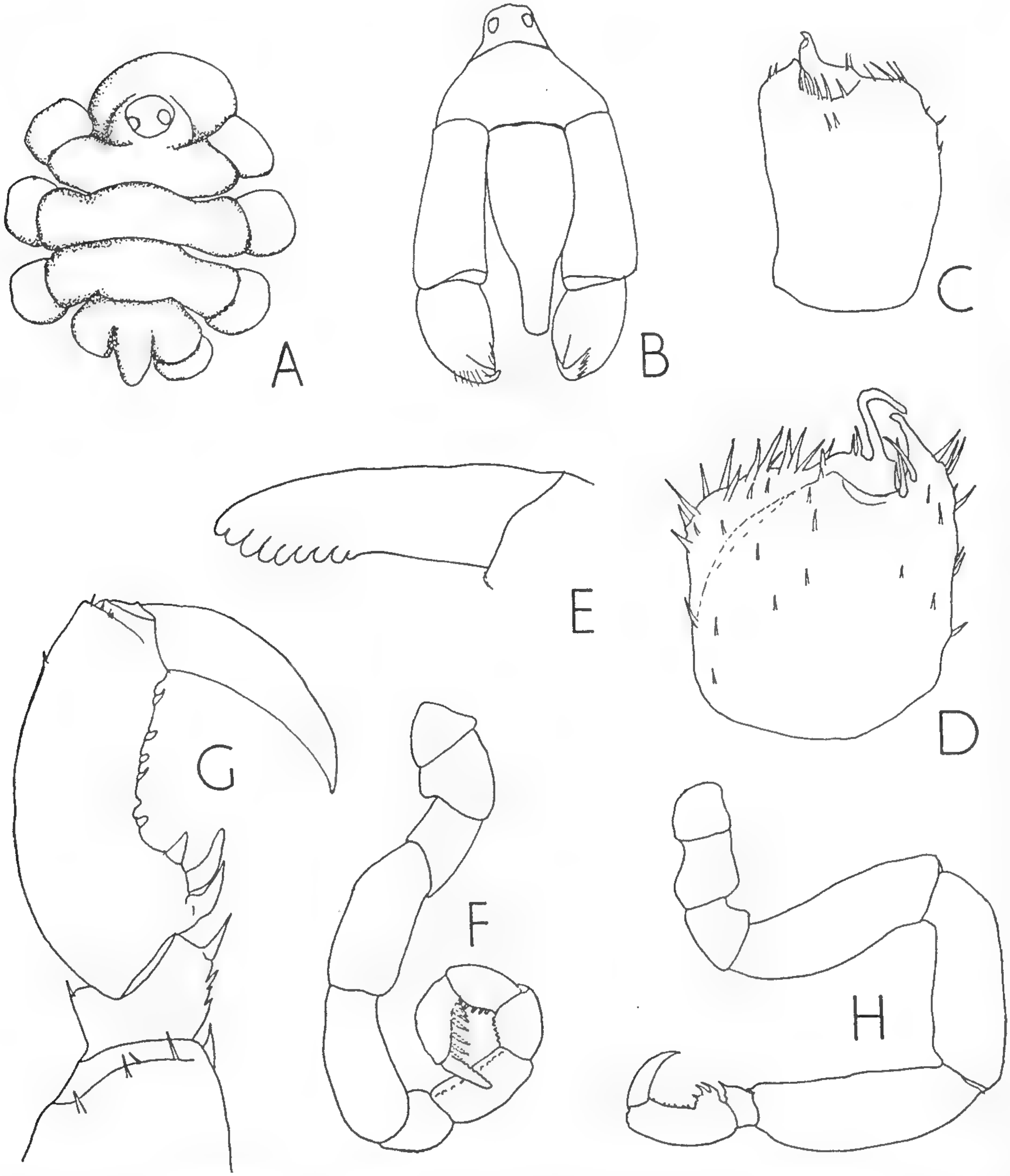

Fig. 17.—A-H, *Pseudopallene dubia* female; A, dorsal view of trunk; B, anterior region; C and D, the two types of chelae; E, terminal oviger claw; F, oviger; G, propodus; H, third leg.

without teeth; in some specimens dactylus is longer than immovable finger, but is then thin and weak.

Palps lacking.

Oviger 10-jointed, fourth and fifth joints about equal and the longest. Denticulate spine formula (female) 10: 5: 5: 6. Terminal claw strong and denticulate throughout distal half of inner edge.

Third leg moderately robust, coxae short, long joints subequal, tarsus short, propodus curved with a well developed heel with large spines. Spines on sole small and sparse. Claw strong, more than half as long as propodus; auxiliary claws lacking.

Measurements (in mm.): Total length (anterior margin of cephalon to tip of abdomen) 1·86, width across second lateral processes 1·2, length abdomen 0·37, length chelifore scape 0·87, length proboscis 0·4. Third leg: 1st coxa 0·31, 2nd coxa 0·49, 3rd coxa 0·36, femur 1·36, 1st tibia 1·18, 2nd tibia 1·28, tarsus 0·18, propodus 0·74, claw 0·45.

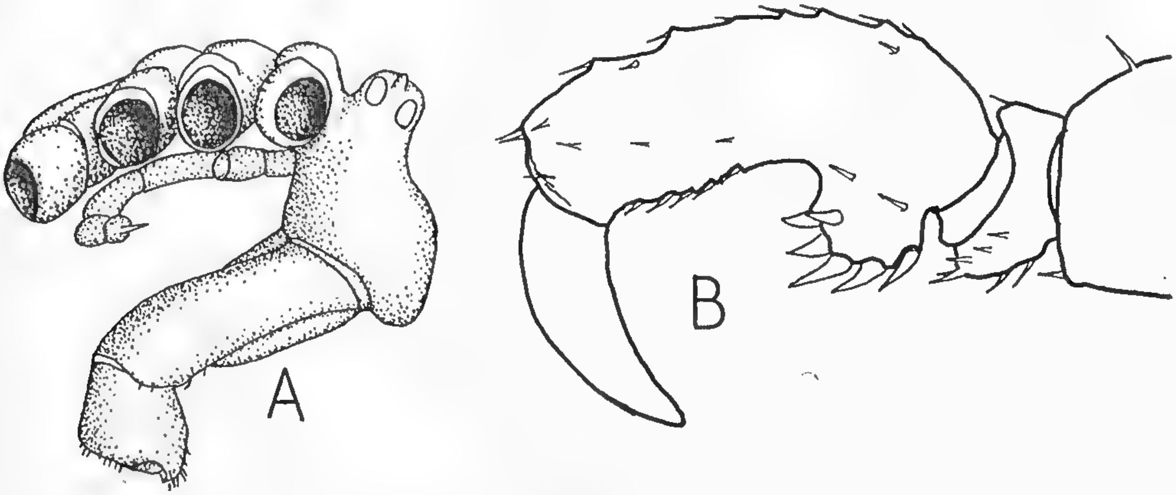

Fig. 18.—A-B, *Pseudopallene dubia* female. A, lateral view of trunk; B, a further propodus.

REMARKS

The difficulty in placing this species in a genus is reflected in the specific name. The general form of the trunk is typical of *Pseudopallene* Wilson, and the form of the proboscis may be regarded as a development of the condition in *Ps. ambigua* Stock and *Ps. zamboangae* Stock with the narrow distal part becoming more elongate. At the same time this type of proboscis may be compared with *Stylopallene* n. gen. The female oviger is similar to both of these genera, as is the propodus with its strongly developed heel. The chelae, on the other hand, ally it through *Ps. zamboangae* to the genus *Cheilopallene* Stock (*C. clavigera* Stock, 1955 and *C. brevichela* Clark, 1961).

Genus **Stylopallene** n. gen.

Callipallenidae. Trunk robust, almost oval in outline, lateral processes almost touching; cephalon well developed, almost equal to rest of trunk, ocular tubercle usually low, rounded, placed in posterior half of cephalon. Proboscis with a broad cylindrical basal part, but tapering to a narrow tubular distal region. Tubular region may be composed of closely apposed or fused lips. Chelifores with one-jointed scape, chelae linear, fingers bowed, untoothed. Palps absent. Oviger 10-jointed in both sexes, with non-denticulated terminal claw, distal apophysis on fifth joint in male often globular. Legs stout, propodus often with a pronounced heel. Auxiliary claws absent.

Type species: *Stylopallene cheilorhynchus* n. sp.

Diagnosis. Callipallenidae with compact robust trunk, distal region of proboscis narrow, tubular. Chelae linear, fingers bowed. Oviger 10-jointed, males with distal apophysis on fifth joint, terminal claw not denticulated. Auxiliary claws wanting.

REMARKS

The tubular elongation of the proboscis and the linear chelae combine with the compact robust trunk to characterize this genus, which is undoubtedly closely allied to *Austropallene* Hodson, *Cheilopallene* Stock, and perhaps to *Pseudopallene* Wilson. The proboscis with its tubular extremity is probably to be viewed as a continuation of the condition seen in *Cheilopallene* spp. where the three lips project from the distal end of the proboscis, but are not fused or even closely apposed, except basally. A series of species *C. clavigera* Stock—*C. brevichela* Clark—*S. cheilorhynchus* n. sp.—*S. tubirostris* n. sp., illustrates the way in which these specialized forms may have arisen. The chelifores most closely resemble those found in *Austropallene*, where a greatly attenuated proboscis is often present. *Austropallene* is, however, always distinguished by the presence of marked spurs over the chelifore bases and on the lateral processes. *Austropallene* is an Antarctic genus, whilst *Stylopallene* is restricted to Australian waters.

Stylopallene cheilorhynchus n. sp.

Figs. 19 A—I

MATERIAL

7 males (1 is holotype), 7 females (1 is allotype), 4 juveniles, Port Arthur, Tasmania, in kelp weed. Coll. Barnett. A.M. P.13634, P.13635, P.13636.

1 juvenile near Mainwaring Cove, west coast of Tasmania, 90 metres, F.I.S. " Endeavour ", June 21, 1914, A.M. E.6393.

DESCRIPTION

Trunk robust, very compact, broad, lateral processes touching, dorsum marked off from lateral processes by integumentary lines; third and fourth trunk segments not separated by a segmental line. Cephalon large, equal to rest of trunk; region anterior to first lateral processes broad with a very slight longitudinal cleft anteriorly.

Ocular tubercle low, rounded, set on posterior part of cephalon; eight eyes arranged in four groups of two.

Proboscis of two parts, a basal cylindrical part and a distal tubular part composed of three lips closely apposed, and greatly developed. Basal part with widest point at two-thirds of its length, tapering slightly towards base and slightly rounded toward base of lip region. Lip region less than half as long as basal region, tapering distally, ending in the pointed tips of the three lips which diverge very slightly at distal extremity.

Abdomen short and broad, rounded, with a downward flexure, reaches beyond ends of fourth lateral processes.

Chelifore scape one-jointed, directed forward and downwards; chelae rather cylindrical in cross-section, palm a little longer than dactylus. Fingers bowed, dactylus rounded, untoothed, but with a few small spinules near outer edge.

Immovable finger strong, slightly nodulous at tip, with a few blunt spinules on side near the tip, and with a number of pointed spinules posterior to these and extending back on to anterior part of palm.

Palps lacking in both sexes.

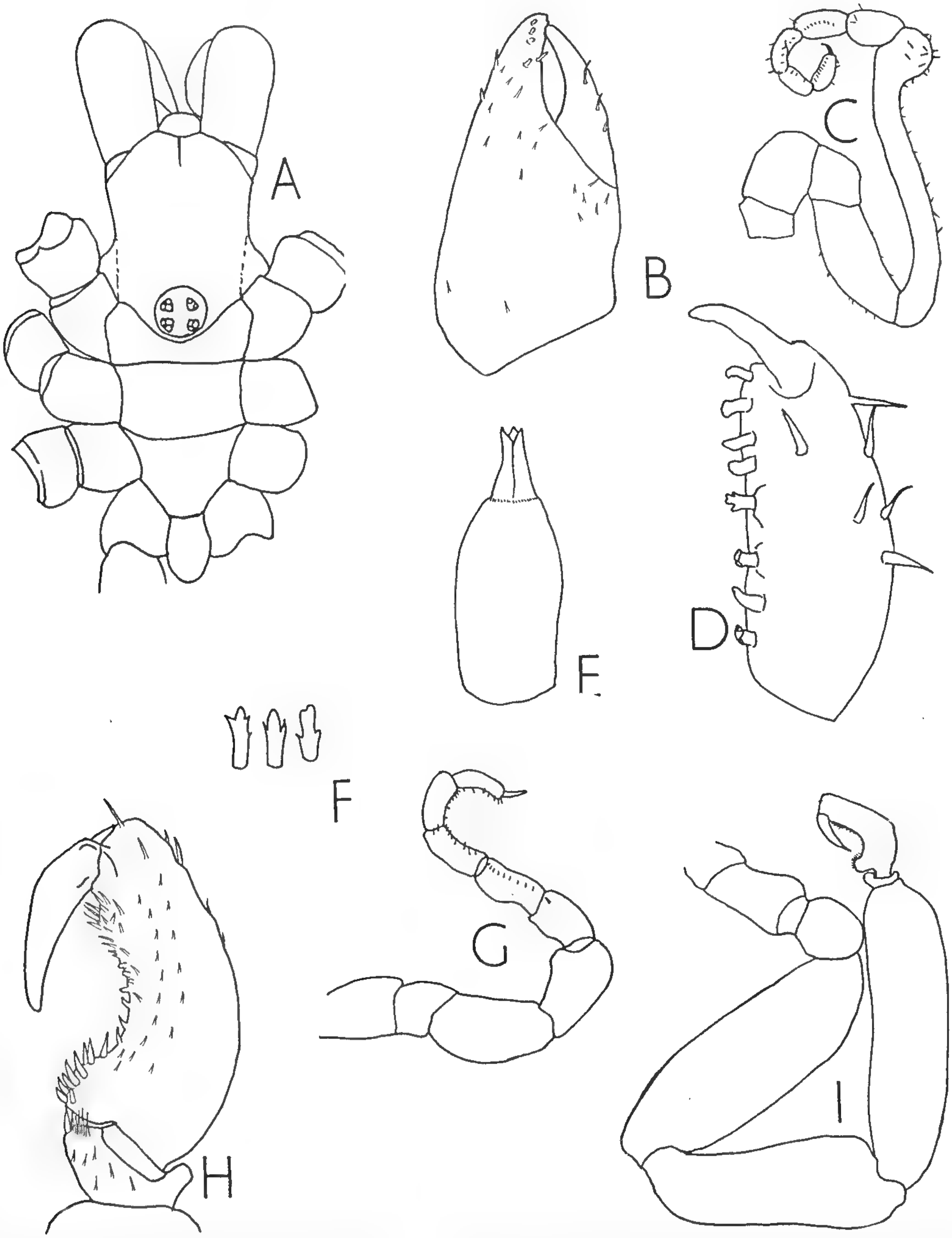

Fig. 19.—A-I, *Stylopallene cheilorhynchus*. A, dorsal view of trunk; B, male chela; C, male oviger; D, tip of male oviger; E, proboscis; F, oviger spines; G, female oviger; H, male propodus; I, male third leg.

Oviger 10-jointed with a terminal claw; in male the three basal joints short and stout, fourth joint long with a few small spines, fifth joint longest, bent, with a marked globular distal apophysis, also with a few small spines. Joints 6-10 decreasing in size, joints 7-10 with denticulate spines according to formula 8 : 7 : 3 : 8. Shape and denticulation of spines are very irregular. Terminal claw non-denticulate. Female oviger somewhat similar to that of male but joint five shorter than joint four, and without any apophysis. Spine formula 9 : 9 : 7 : 6. Length of joints in mm. are:

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·27	0·46	0·4	1·0	1·91	0·36	0·34	0·29	0·23	0·25
Female ..	0·27	0·46	0·31	0·81	0·545	0·545	0·46	0·37	0·34	0·34

Third Leg. Legs stout, second coxa longer than first or third, long joints strongly inflated with a sparse investiture of small spinules, femur and second tibia subequal, first tibia a little shorter; tarsus very short, propodus curved with a strong heel. Basal spines of heel region moderate, but weaker on distal parts of sole, many small spinules on sides of the propodus. Claw strong, half as long as propodus; auxiliary claws lacking.

Genital pores on ventral surfaces of second coxae of all legs in both sexes.

Measurements (in mm.—male paratype): length trunk (anterior margin of cephalon—tip of abdomen) 2·86, length cephalon 1·4, width second lateral processes 1·7, length chelifore scape 0·86, length abdomen 0·6, length proboscis 1·2, greatest width proboscis 0·7. Third leg: 1st coxa 0·47, 2nd coxa 0·86, 3rd coxa 0·6, femur 2·34, 1st tibia 2·26, 2nd tibia 2·73, tarsus 0·2, propodus 0·93, claw 0·47.

Stylopallene dorsospinum n. sp.

Figs. 20 A—I

MATERIAL

2 females (one is holotype) trawled about seven miles off Twofold Bay, N.S.W., 90 metres. Coll. Capt. K. Moller, trawler "Durraween" Oct., 1929. A.M. P.13637, P.13638.

1 damaged male (allotype), 1 female, 2 juveniles, trawled of Wata Mooli, near Botany Bay, N.S.W. (3½-4 miles), 91-93 metres, dredged, Station 57, "Thetis" Expedition. A.M. P.13639 (2 parts).

DESCRIPTION

Trunk very compact, robust, clearly segmented, lateral processes touching or nearly touching, with one or two terminal or sub-terminal tubercles; central area of dorsum marked off from lateral processes by lateral grooves reminiscent of *Rigona*. Cephalon large, very broad, region anterior to ocular tubercle greatly expanded, forming massive bases to chelifore scapes. Low tubercles present over bases of chelifores. Posterior portions of segments 1-3 thrown up into pronounced ridges, which on segments two and three are surmounted by tall, tapering, cylindrical processes which may bear a few setae.

Ocular tubercle situated between anterior margins of first lateral processes, anterior face about 1½ times as high as basal diameter, rounded above with a slight transverse apical groove; eyes four, well-pigmented.

Abdomen stout, set at 45° from horizontal, taller than ocular tubercle but lower than dorsal tubercles, anus a terminal slit.

Proboscis consisting of two regions, a pear-shaped basal part and a distal, slender tapering part composed of the closely apposed and partly fused lips. Proboscis rather similar to that of *S. tubirostris* n. sp. but the regions are not demarcated by transverse lines.

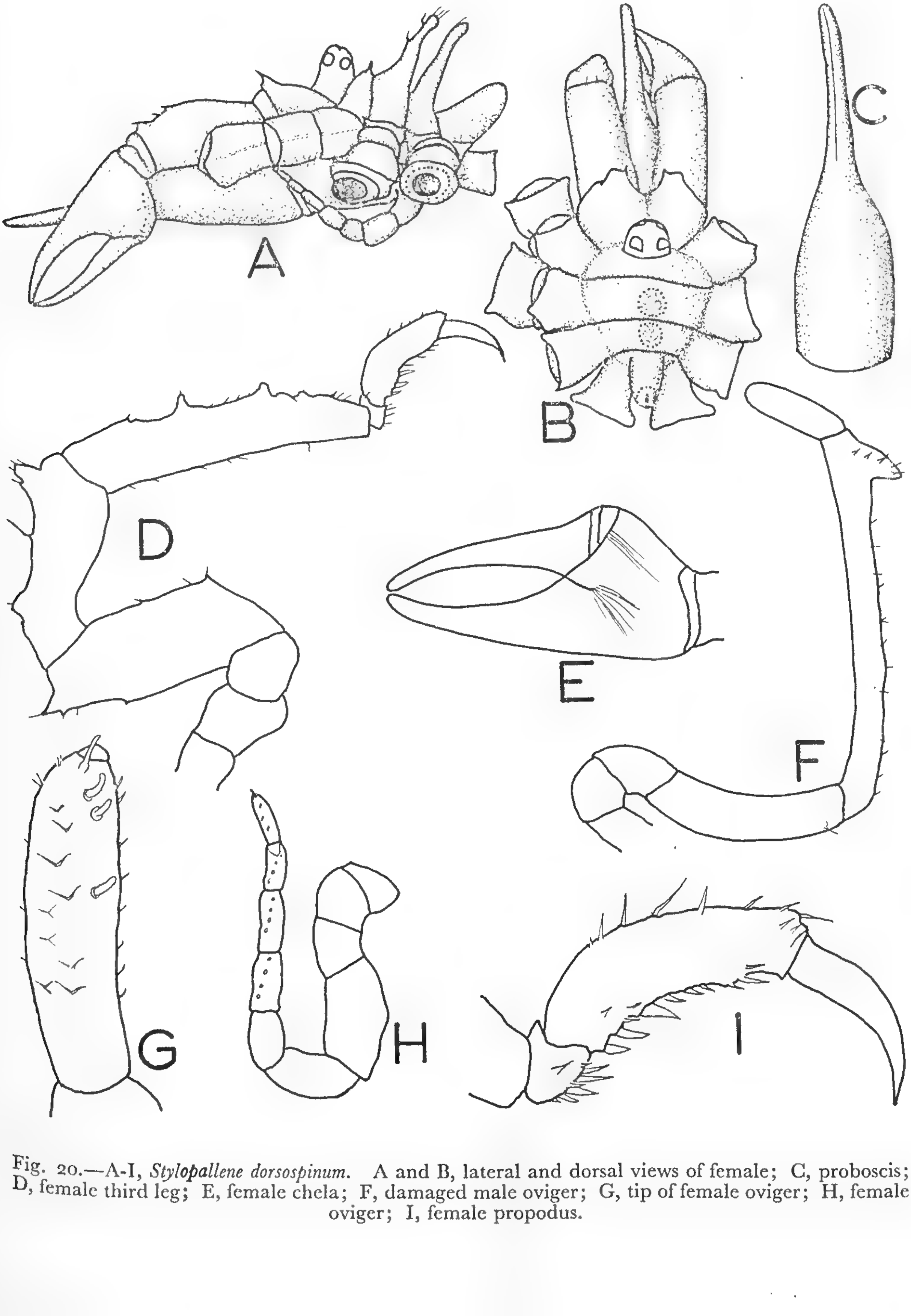

Fig. 20.—A-I, *Stylopallene dorsospinum*. A and B, lateral and dorsal views of female; C, proboscis; D, female third leg; E, female chela; F, damaged male oviger; G, tip of female oviger; H, female oviger; I, female propodus.

Chelifore scape one-jointed with a few small spines near distal end. Chela linear, strong, fingers longer than palm, dactylus and immovable finger equal, slender, gently bowed, untoothed, meeting at tips.

Palps lacking.

Oviger (female) 10-jointed, joints 1-3 short and stout, fourth joint stoutest and longest, fifth shorter than fourth and three-quarters as wide; joints 6-10 subequal in length becoming progressively more slender. Terminal joint difficult to interpret, possessing a terminal boss-like structure which is interpreted as the remnant of a terminal claw, joints 7-10 each bear four reduced compound (?) oviger spines and a number of bifid and trifid setae.

The only male specimen available bears a single damaged oviger from which the following information may be derived: joints 1-3 short and stout, fourth joint longer than any joint of the female oviger, fifth joint almost twice as long as fourth, with a marked distal apophysis, short setae present along one edge of joint and several spines on apophysis; sixth joint shorter than fourth.

Third leg stout, robust, coxae subequal, femur solid with strong spine bearing tubercle distally, first tibia shorter and more slender than femur, also armed with spine bearing tubercles, 2nd tibia the longest joint, with tubercles on dorsal surface. Tarsus short, propodus slightly curved with strong spines on heel region but weaker further along sole; claw strong, more than half as long as propodus, auxiliary claws absent.

Genital pores, both sexes, on ventrodistal part of second coxae of all legs.

Measurements (figured paratype in mm.): length trunk (anterior margin of cephalon to tip 4th lateral processes) 1·98, length cephalon 0·84, width 2nd lateral processes 1·8, length proboscis 2·35, greatest width proboscis 0·61. Third leg: 1st coxa 0·48, 2nd coxa 0·51, 3rd coxa 0·485, femur 1·88, 1st tibia 1·62, 2nd tibia 2·35, tarsus 0·15, propodus 0·85, claw 0·56.

REMARKS

In the form of the proboscis this species is very similar to *S. tubirostris* n. sp. It is readily distinguished from *S. tubirostris* and *S. cheilorhynchus* by the dorsal tubercles and the long fingers of the chelae. The oviger is more reduced than in any of the other species.

Stylopallene tubirostris n. sp.

Figs. 21 A—I

MATERIAL

1 ovigerous male (holotype) Port Jackson, N.S.W., Nov. 7, 1927. A.M. P.6744.

DESCRIPTION

Trunk very compact, clearly segmented, lateral processes touching or nearly touching, surface of dorsum smooth, not ornamented by spines or setae. Cephalon large, equal in length to remaining three segments; anterior portion expanded over base of proboscis. Trunk segments marked with lateral lines running from anterior to posterior margins in a manner reminiscent of those found in *Rigona*.

Ocular tubercle very low, in line with first lateral processes, and thus situated two-thirds of the way back from anterior margin of cephalon; eyes small, well pigmented; appear to be eight in number arranged in four groups of two.

Abdomen horizontal, short, reaching beyond fourth lateral processes, but not beyond first coxae.

Proboscis consisting of two distinct regions; a moderately stout basal region, and a long tubular distal region of about the same length as basal region. Proximal portion of basal region slightly expanded, then narrowing slightly, to continue as a cylinder towards distal part of this region when it becomes much narrower at base of tubular region. Tubular region about one-fifth as wide as basal region, tapering slightly throughout its length.

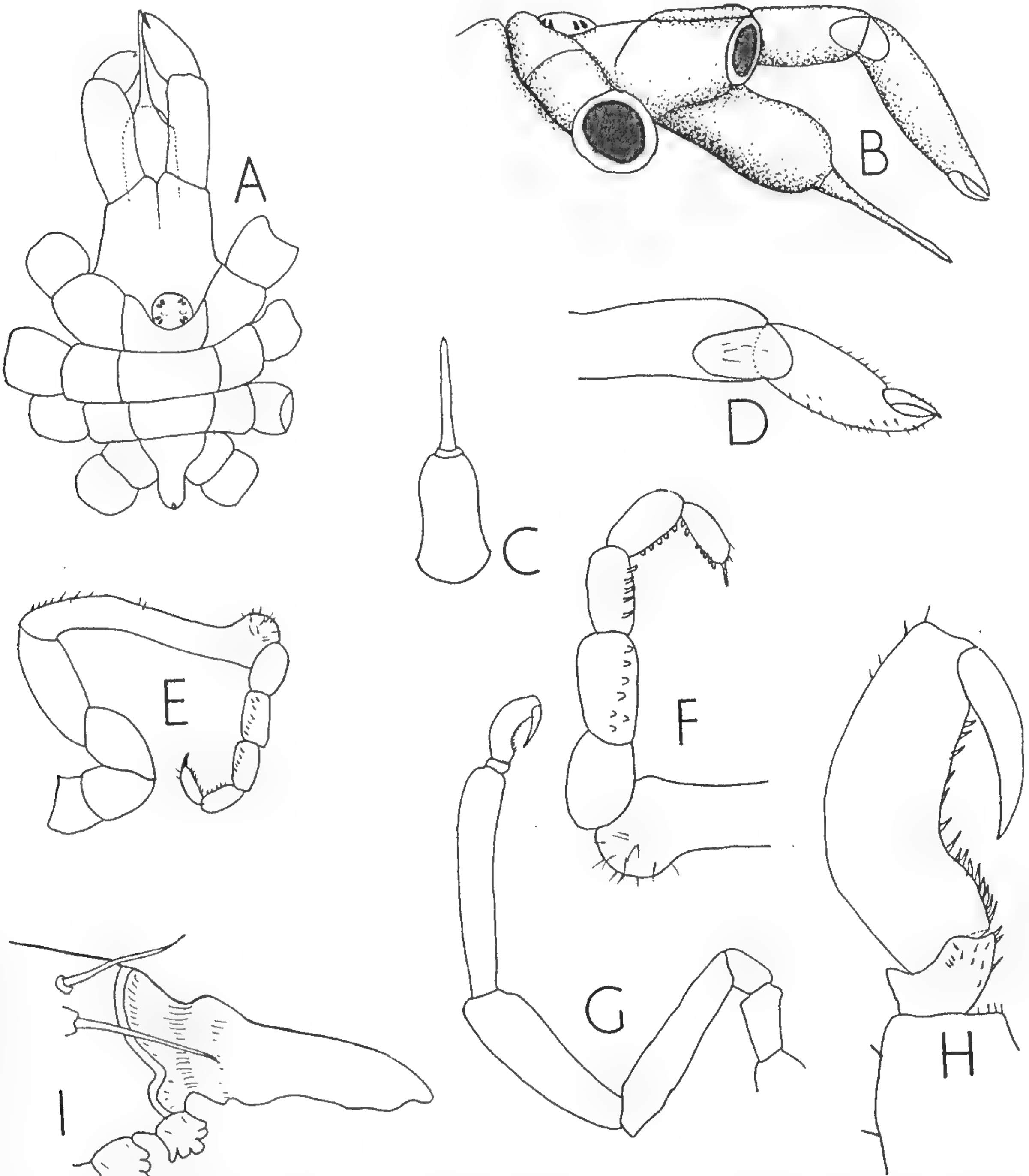

Fig. 21.—A-I, *Stylopallene tubirostris* (all figs. of male holotype). A, dorsal view of trunk; B, lateral view of cephalic region; C, proboscis; D, chela; E, oviger; F, tip of oviger; G, third leg; H, propodus; I, terminal oviger claw.

Chelifores linear, scape one-jointed, smooth. Chelae linear-ovate, palm about twice as long as fingers, dactylus curved, immovable finger almost straight, fingers not toothed. Chelae with a few short setae scattered irregularly over surface.

Palps lacking.

Oviger 10-jointed, joints 1-4 normal, fifth joint with a marked globular terminal swelling which bears a number of simple setae; joints 7-10 with denticulate spines according to formula 7 : 5 : 5 : 7. Terminal claw present. Oviger joints of the following lengths (in mm.): 1—0·44, 2—0·476, 3—0·44, 4—0·95, 5—1·965, 6—0·393, 7—0·419, 8—0·375, 9—0·321, 10—0·245.

Third leg robust, slight ventral swellings on distal ends of all second coxae bear genital apertures. There do not appear to be any femoral cement glands. Femur and tibia stout, almost spineless; propodus slightly arcuate; basal spines uniform in size, more closely spaced in heel region. Claw strong, auxiliary claws lacking.

Measurements (in mm.): Total length (tip proboscis to fourth lateral processes) 3·75, width 2nd lateral processes 1·78, length chelifore scape 0·9, abdomen 0·32, proboscis (measured ventrally) basal region 0·98, stylar region 0·8, total length 1·78, width proboscis at base 0·59, width at distal part of basal region 0·54. Third leg: 1st coxa 0·45, 2nd coxa 0·93, 3rd coxa 0·89, femur 2·68, 1st tibia 2·5, 2nd tibia 2·95, tarsus 0·43, propodus 1·18, claw 0·675.

Key to Species of **Stylopallene**

1. Dorsum with tubercles taller than ocular tubercle, propodal heel poorly developed *S. dorsospinum* n. sp.

   Dorsal tubercles not taller than ocular tubercles, propodal heel moderately developed. 2.

2. Proboscis with narrow distal part less than half as long as wider basal part. *S. cheilorhynchus* n. sp.

   Proboscis with narrow distal part almost as long, or as long as wider basal part. *S. tubirostris* n. sp.

Genus **Pallenopsis** Wilson, 1881

Pallenopsis hoekii Miers

Fig. 24E

Pallenopsis hoekii Miers, 1884; 324, pl. 35, fig. B.

——Carpenter, 1893; p. 23, pl. 2, fig. 11.

? *Phoxichilidium hoeckii* Haswell, 1884; 1022. ——Loman, 1908; 70-71.

Pallenopsis (*Rigona*) *rigens* Loman, 1908: 68-69, pl. 9, fig. 128-133.

Pallenopsis (*Rigona*) *hoekii* Flynn, 1929: 257-258.

Pallenopsis hoeki Stock, 1954: 8.

REMARKS

During the preparation of the key to Australian species in this genus I examined the type material in the British Museum and found that the figures of the oviger already published are inadequate. I have therefore provided a new figure of the terminal joints of one of the syntypes.

Pallenopsis gippslandiae Stock

Fig. 22 I

Pallenopsis gippslandiae Stock, 1954: 65-68, figs. 28-29.

MATERIAL

1 ovigerous male, off mouth of Manning River, N.S.W., 84-93 metres, trawler " Ben Bow ", pres. Capt. K. Moller, March 17, 1947. A.M. P.11755.

4 ovigerous males, 5 females, trawled 25 miles south-east of Double Island, Queensland, 62 metres, F.I.S. " Endeavour ". A.M. P.13640.

1 female, trawled 40 miles south-south-west off Mt. Cann, Vict., 130 metres F.I.S. " Endeavour ", March 27, 1914. A.M. P.13641.

1 female, trawled off Green Cape, N.S.W., coll. Capt. K. Moller, July, 1926. A.M. P.13642.

2 males (1 ovigerous), 2 females, trawled 30 miles south of Gabo Island, N.S.W., 148 metres, coll. Capt. K. Moller, trawler " Durraween ", July, 1939. A.M. P.13643.

1 male, trawled 11 miles west by west off Crowdy Head, 93 metres, coll. Capt. K. Moller, Sept., 1935. A.M. P.11761.

1 female, no data, found in tube associated with the young of the crab *Latreillopsis petterdi* Grant (P.6776), a species occurring off the south-east and south coastline of Australia in deep water. From an F.I.S. " Endeavour " locality. A.M. P.13644.

1 female, off Disaster Bay, N.S.W., about 95 metres, trawled, coll. Capt. K. Moller, May, 1930. A.M. P.13645.

2 females (1 immature) off Botany Bay, N.S.W., 61-99 metres, taken from ground line of trawl on trawler " Karangai ", coll. F. McNeill and A. Livingston, Aug., 1921, A.M. P.5597 (part).

1 ovigerous male, off Cape Everard, Vict., 130-140 metres, coll. H. O. Fletcher, trawled May, 1929. A.M. P.13646.

1 juvenile, 10 miles off Montague Island, N.S.W., 130-148 metres, " Bar-ea-Mull ", coll. G. P. Whitley and W. Boardman, Aug. 24, 1925. A.M. P.8220.

1 female, 25 miles south of Cape Everard, Vict., 150 metres, F.I.S. " Endeavour ", Oct. 20, 1914. A.M. E.6029.

1 male, east of Babel Island, eastern slope Bass Strait, 122 metres, trawled F.I.S. " Endeavour ", May 28, 1914. A.M. P.13647.

20 males, 17 females, 1 juvenile, trawled west-south-west from Gabo Island, N.S.W., 130 metres, coll. Capt. K. Moller, trawler " Durraween ", Dec., 1929. A.M. P.13648.

1 female (abnormal ocular tubercle), off Babel Island, eastern slope Bass Strait, 148-555 metres, F.I.S. " Endeavour ", 28 May, 1914, A.M. E.4650.

4 males, 3 females, trawled about 7 miles off Twofold Bay, N.S.W., 83 metres, coll. Capt. K. Moller, trawler " Durraween ", Oct., 1929. A.M. P.13649.

2 females, 1 juvenile, trawled off Twofold Bay, N.S.W., 83-93 metres, " Durraween ", coll. Capt. K. Moller, Aug., 1929. A.M. P.13650.

REMARKS

Although this species was previously known only from two males, the description provided by Stock is adequate for both sexes, though in the females the spine-bearing tubercles on the central third of the femur are not always as numerous as in the males. The ocular tubercle is often rather more pointed than shown in Stock's figures.

One female from off Babel Island is abnormal in that the ocular tubercle is bifid at the tip and bears eight eyes. A frontal view of this ocular tubercle is shown in fig. 22 I.

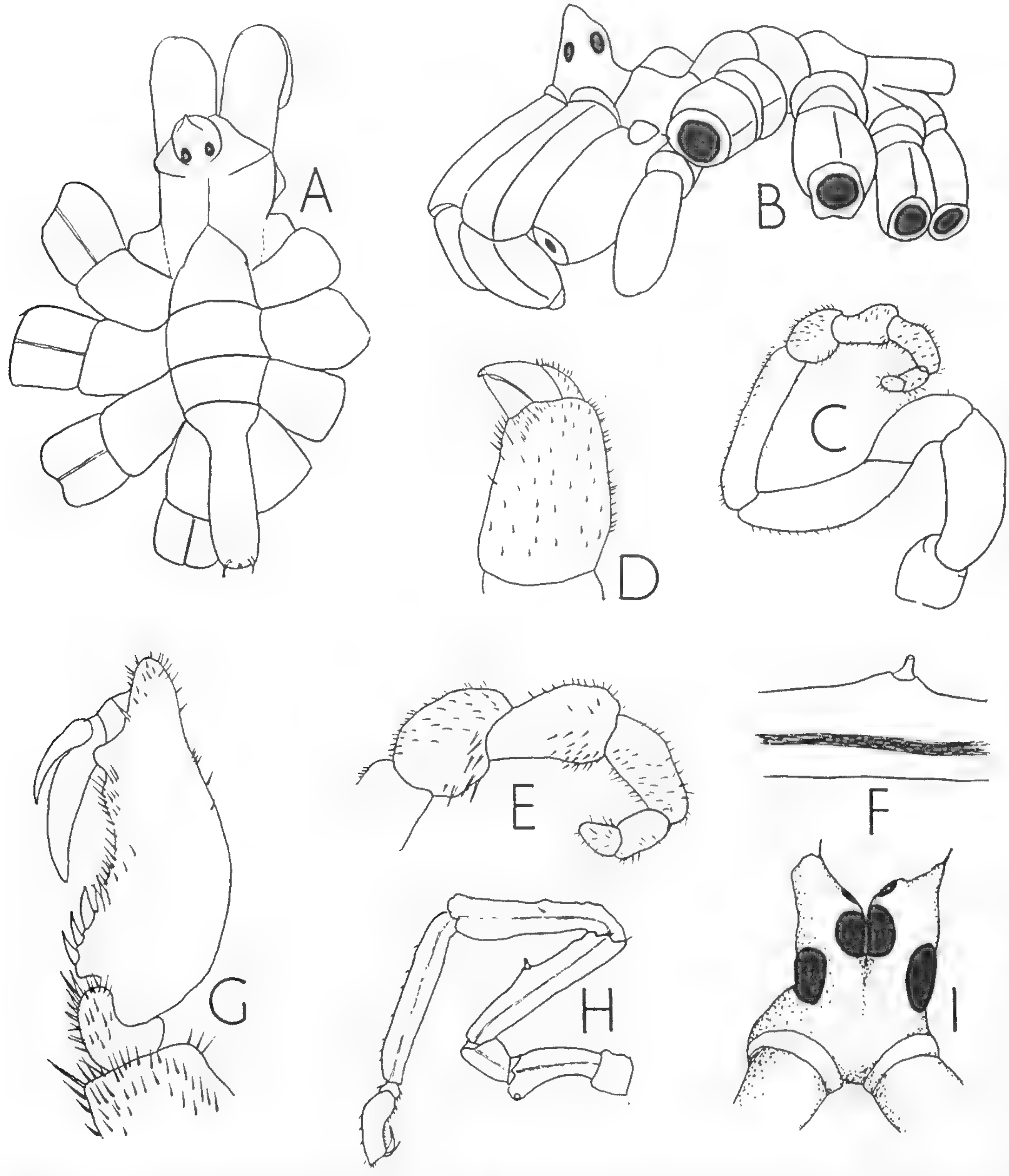

Fig. 22.—A-H, *Pallenopsis macneilli.* A, dorsal view of male paratype; B, lateral view of female paratype; C, male oviger; D, male chela; E, tip of male oviger; F, femoral cement gland duct; G, male propodus; H, male third leg; I, *Pallenopsis gippslandiae*, anterior view of ocular tubercle of abnormal specimen.

Pallenopsis macneilli n. sp.

Figs. 22 A—H

MATERIAL

1 male (holotype) and 5 females (1 is allotype, the rest paratypes), Nelson's Bay, Port Stephens, N.S.W., A.M. P.13651, P.13652, P.13653.

1 damaged larvigerous male, on weed, low-tide mark, Bondi, coast near Sydney, N.S.W., Nov., 1927, coll. M. Ward. A.M. P.8930.

1 juvenile, Shoreline Cave, Narooma, N.S.W., among growths in rock pool, coll. Miss E. Pope, July 15, 1949. A.M. P.11952 (part).

DESCRIPTION

Trunk compact, robust, without spines or tubercles except at tip of abdomen. Lateral processes touching or almost touching throughout length. Trunk typical of type found in subgenus *Rigona*, i.e., lateral processes are marked off from central portion of trunk segments by transverse cuticular grooves, central region rather inflated. Segmental lines moderately well-developed in males, but somewhat obscured in some females. Anterior portion of cephalon bears at its tip the ocular tubercle, and, posterior to this and extending in mid-line to anterior limit of central swollen portion of trunk, is a dark, somewhat depressed line in the cuticle. Oviger bases inserted on ventral side of neck region of cephalon, immediately anterior to first lateral processes.

Ocular tubercle slightly higher than diameter at base, roundly conical at tip, without setae. Four well-pigmented eyes.

Proboscis cylindrical, length about twice diameter, slightly constricted at one-third and two-thirds of its length.

Abdomen reaches to tip of first coxa, slightly narrower near base than at two-thirds of its length where it reaches its maximum width. Tip truncated, and armed with two small spines. Abdomen may be horizontal or slightly elevated.

Chelifore scape of one joint, widening slightly towards distal end; with short sparse pubescence near distal end. Chela two-thirds of length of scape, palm rather rectangular, fingers about half as long as palm, dactylus a little longer than immovable finger, tips of fingers cross, cutting edges untoothed. At base of dactylus is a small pad furnished with short setae, another group of slightly longer setae is present at base of immovable finger. Palm bears a number of short sparse hairs.

Palp a single knob-like joint inserted ventro-laterally on cephalon level with posterior part of ocular tubercle.

Oviger (holotype—male) of 10 joints, fourth and fifth joints longest, sixth joint short and stout; terminal joints as shown in fig. 22E. Compound spines lacking. Orientation of the simple setae appears almost random. Female oviger (allotype) nine-jointed, weaker than that of male, basal joint not as robust as in male and fourth joint is longest; apart from ninth joint, almost without setae. Ninth joint bears five moderate and one small simple oviger spines.

The measurements of the oviger joints (in mm.) are:

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·66	1·22	0·88	1·6	1·72	0·5	0·5	0·8	0·25	0·17
Female ..	0·3	0·33	0·28	0·67	0·55	0·33	0·48	0·2	0·16	—

Third leg stout, robust, with few short hairs. First coxa one-third as long as second, which is almost twice as long as third. Femur and first tibia equal, femoral cement glands of male with ducts about one third as long as width of femur, inserted on a mound about middle of femur. Second tibia longest joint, and tarsus shortest. Propodus curved, more markedly so on dorsal surface; with a spinose distal process. The three proximal basal spines are strong; remainder weak. Terminal claw strong, reaching to tip of third basal spine; auxiliary claws two-thirds as long as main claw.

Measurements (in mm., male holotype) length proboscis (measured ventrally) 1·9, greatest width proboscis 0·9, length (tip of cephalon to tip 4th lateral process) 4·2, width second lateral processes 3·1, length chelifore scape 1·7, length abdomen 1·2. Third leg: 1st coxa 0·77, 2nd coxa 2·3, 3rd coxa 1·3, femur 3·8, 1st tibia 3·8, 2nd tibia 4·2, tarsus 0·3, propodus 1·6, claw 0·7, auxiliary claw 0·46.

Genital apertures on small swellings on ventral surfaces of distal portions of all second coxae in females, but only third and fourth pairs of legs in males. Genital mounds larger in males.

REMARKS

This species is at first sight rather similar to several other species of *Pallenopsis* known from this general region. It differs from *P. hoekii* Miers in the possession of the setose pad at the base of the chelifore dactylus, the closer spacing of the lateral processes, the shape and spination of the propodus, as well as fundamental differences in the ovigers. It differs from *P. ovalis* Loman in the lesser development of the genital mound in the male, the reduced spination of the male oviger, and the well-developed intersegmental lines in the male. In *P. ovalis* the integument is reticulated, but not in *P. macneilli*. Similarly, it is readily distinguished from the New Zealand *P. obliqua* (Thomson) by the lack of spines and tubercles on the trunk and chelifore scape. Further, this species may be distinguished from *P. persimilis* Stock by the presence of the full complement of intersegmental lines and the absence of setae on the ends of the lateral processes. More important features are found in the male oviger, which lacks the terminal process on the sixth joint that is found in *P. persimilis*, and the reduced spination of the female oviger. The ocular tubercle and propodus also differ. There can be no doubt that *P. macneilli* is closely related to the *P. ovalis-obliqua-persimilis* group, but a comparison of this species with the others discussed by Stock (1956b) shows this new species to differ from those previously known.

Key to the Australian species of **Pallenopsis**

1. Trunk very compact, lateral processes touching or almost touching. — 2

   Trunk not very compact, lateral processes separated by almost their own width. — *P. gippslandiae* Stock.

2. Proboscis with a fringe of setae near tip. — *P. denticulata* Hedgepeth.

   Proboscis without a fringe of setae near tip. — 3

3. With a setose pad at base of chelifore dactylus. — *P. macneilli* n. sp.

   Without a setose pad at base of chelifore dactylus. — *P. hoekii* Miers.

Genus **Pycnothea** Loman, 1921

Pycnothea flynni Williams

Figs. 23 A—G

Pycnothea flynni Williams, 1940: 202-204, figs. 6-9.

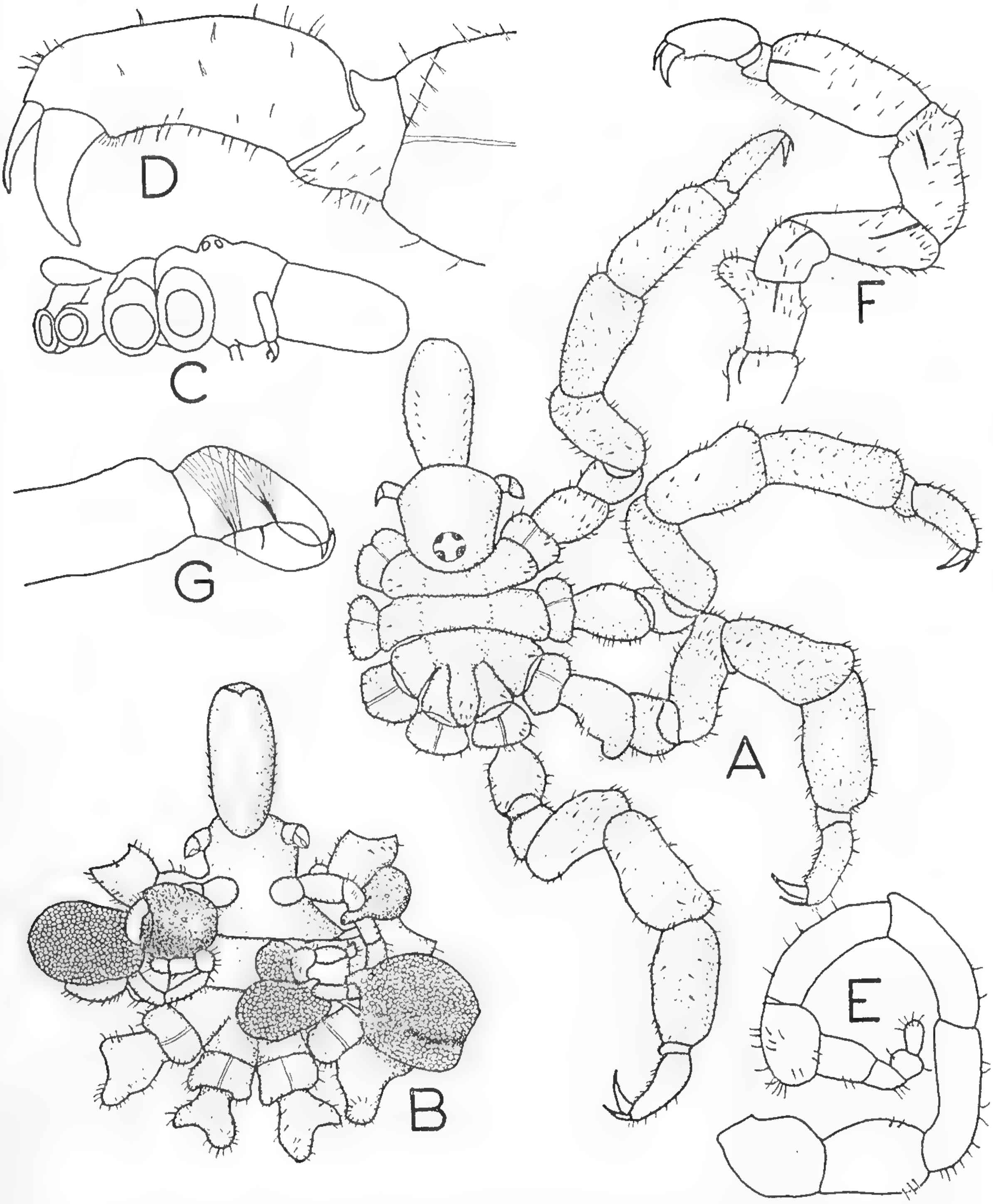

Fig. 23.—A-G, *Pycnothea flynni* male. A, dorsal view; B, ventral view showing egg masses; C, lateral view; D, propodus; E, oviger; F, third leg; G, chelifore.

MATERIAL

1 ovigerous male, Norfolk Island, coll. W. Laing, 1902 (in writer's collection).

1 male, reef at Shelly Beach, west mouth of Clarence River, N.S.W., coll. A. Cameron, Jan., 1939. A.M. P.11018.

1 ovigerous male, under stones, Angowrie, south of Clarence River, N.S.W., coll. Miss E. Pope, April 6, 1947, A.M. P.11951.

REMARKS

One specimen was noted as uniformly red in colour in life; in alcohol all specimens were straw-coloured.

P. flynni, hitherto only known from Rottnest Island, Western Australia, is now recorded from the eastern coast and from Norfolk Island. The only other species in this genus is *P. selkirki* Loman, from Juan Fernandez Island.

Pycnothea stands very close to *Pigrogromitus* Calman, from which it is distinguished by the single jointed chelifore scape, the presence of auxiliary claws and the absence of a terminal oviger claw. *Pigrogromitus* is monotypic (*P. timsanus* Calman, 1927); *Pigrogromitus robustus* Hilton, 1942, is in fact *Pycnosoma strongylocentroti* Los.—Los. (Hedgepeth *in litt.*).

Family **PHOXICHILIDIIDAE** Sars, 1891

Genus **Anoplodactylus** Wilson, 1878

Anoplodactylus haswelli (Flynn)

Figs. 24 A—D

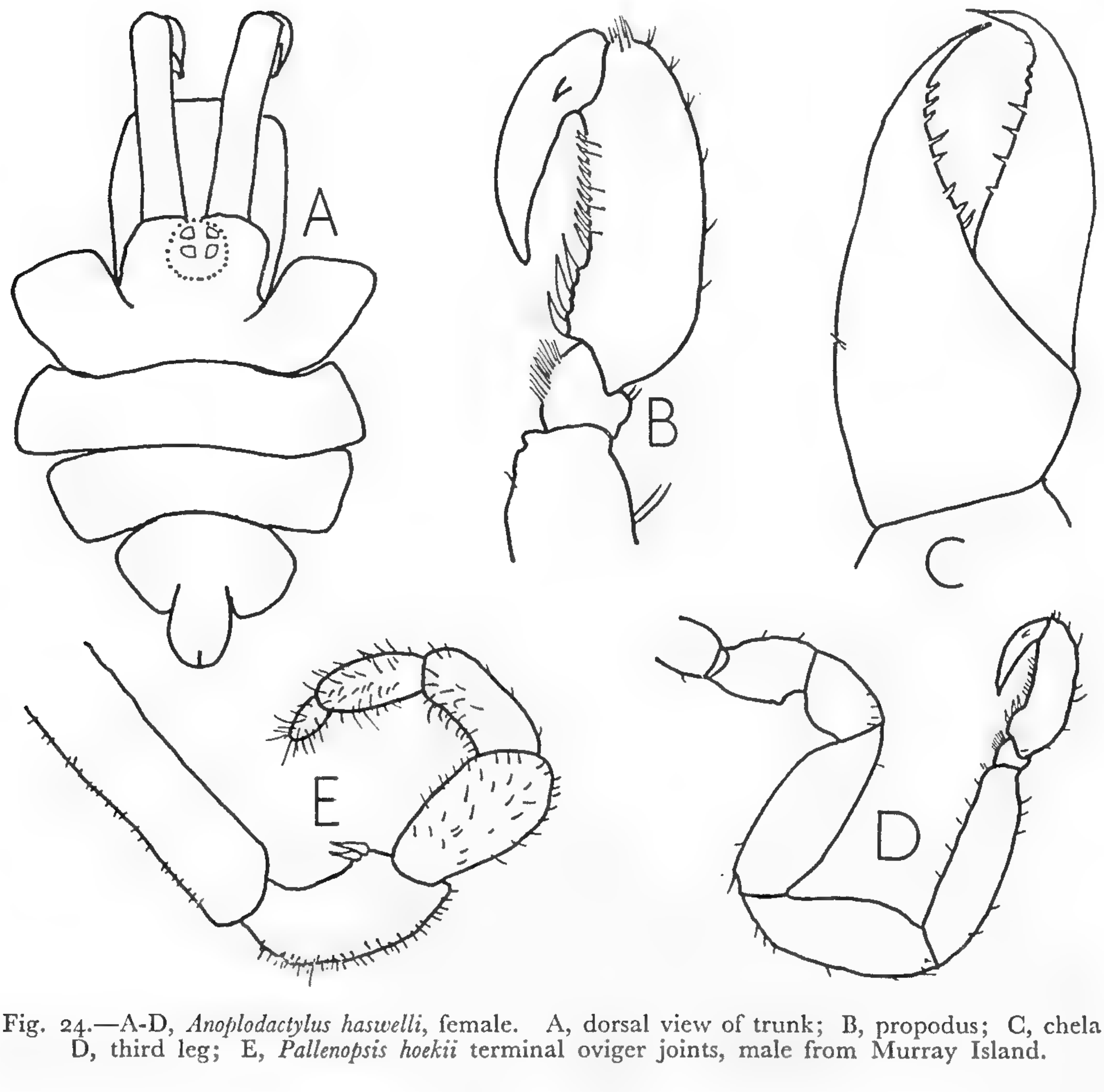

Fig. 24.—A-D, *Anoplodactylus haswelli*, female. A, dorsal view of trunk; B, propodus; C, chela; D, third leg; E, *Pallenopsis hoekii* terminal oviger joints, male from Murray Island.

Halosoma haswelli Flynn, 1919a: 11-15, pl. 1.

Anoplodactylus haswelli Stock, 1954: 86-88, fig. 40 a, b.

MATERIAL

4 females, Burning Palms Beach, south of Port Hacking, N.S.W., rocks near high tide mark, coll. G. P. Whitley, Feb. 11, 1934. A.M. P.10506 (part).

REMARKS

The females of this species are new, the species being previously known from two males. Some of the differences noted may be sexual in character. The females differ from Flynn's description in having the intersegmental lines well developed on the dorsal side, and strikingly in the spination of the tarsus and propodus. Further, the femora and tibiae do not all possess the terminal spine which is so prominent in Flynn's figures. In other characters they agree well enough, even to measurements. These specimens differ strikingly from the chelifore figured by Stock (1954). Stock's specimen came from New Zealand and undoubtedly represents a different species.

Measurements (in mm.): total length (tip proboscis to tip fourth lateral processes) 1·04, width across second lateral processes 0·7, length proboscis 0·57, greatest width proboscis 0·38, length chelifore scape 0·47. Third leg: 1st coxa 0·19, 2nd coxa 0·38, 3rd coxa 0·38, femur 0·78, 1st tibia 0·81, 2nd tibia 0·82, tarsus 0·09, propodus 0·55, claw 0·35.

The genital apertures are situated on very small papillae on the ventral surface of all second coxae.

Anoplodactylus tubiferus (Haswell)

Phoxichilidium tubiferum Haswell, 1884: 1032, pl. 57, figs. 1-5. ——Whitelegge, 1889: 233.

Anoplodactylus tubiferus Cole, 1904: 288. ——Loman, 1908: 72. ——Flynn, 1920: 79-81, pl. xx, figs. 12-14, pl. xxi, fig. 15 ——Williams, 1941: 35.

MATERIAL

1 male off Cape Everard, Vict., 126-135 metres, trawled, coll. H. O. Fletcher, May, 1929. A.M. P.13654.

1 male, 1 female, station 37, " Thetis " Expedition, 2-2½ miles off Botany Bay, N.S.W., 90-93 metres, dredged. A.M. P.13655.

1 male, station 35, " Thetis " Expedition, 1¼-2 miles off Port Hacking, N.S.W., 39-69 metres, dredged. A.M. P.13656.

REMARKS

The material before me does not differ in any respect from the descriptions of Haswell or Flynn. *A. tubiferus* is readily distinguished from all other Australian species of the genus by the great height of the ocular tubercle. The only other species with a high ocular tubercle is *A. longiceps* which has a pointed ocular tubercle and low, broad cement glands in the males. In *A. tubiferus* the cement glands discharge through a long fine tubular duct more than one third as long as the femur

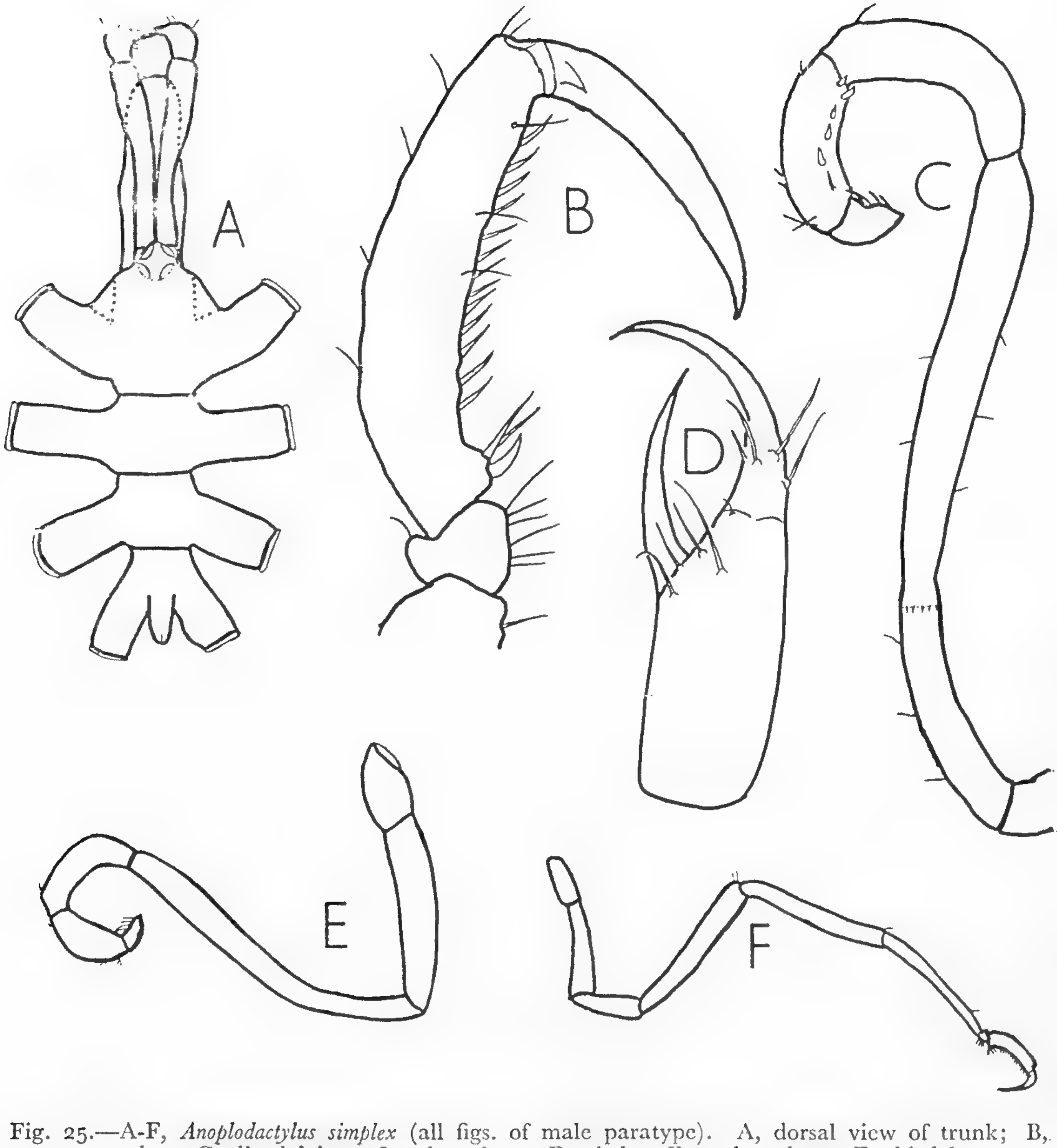

Fig. 25.—A-F, *Anoplodactylus simplex* (all figs. of male paratype). A, dorsal view of trunk; B, propodus; C, distal joints of male oviger; D, chela; E, male oviger; F, third leg.

Anoplodactylus simplex n. sp.

Figs. 25 A—F

MATERIAL

2 ovigerous males, 8 females (1 male is holotype, a female is allotype, the remainder are paratypes), Shallow Bay, just south of Kurnell, Botany Bay, N.S.W., dredged in 15 feet, sand and weed, coll. F. McNeill and party. A.M. P.8938.

DESCRIPTION

Trunk clearly segmented, lateral processes separated distally by their own diameter or more. Surface of trunk and lateral processes smooth, without spines or other ornament.

Ocular tubercle tall, obtusely pointed, directed slightly forward, eyes not well pigmented.

Abdomen slightly tapering towards tip, directed upwards at nearly 90°.

Proboscis long, cylindrical, inflated near middle.

Chelifore scape slender, wider distally, reaching over proboscis, with a few small setae; chelae at right angles to proboscis, fingers about same length as palm, dactylus strongly curved, immovable finger less strongly curved, margins of both fingers entire. Four simple spines on palm near base of fingers, and on sides of dactylus.

Palps lacking in both sexes.

Oviger (in male only) six-jointed, third joint longest, with a trace of an unarticulated joint near proximal end; fourth and fifth joints curved, sixth joint very short, third and fourth joints with sparse fine setae, fifth joint with fine setae and five short peg-like spines near inner margin; terminal joint armed with a stout proximal spine, and beyond this two fine setae.

Legs moderately stout, femur the longest joint. Propodus with a strong heel, armed with a stout spine proximally, and a pair of longer and more slender spines distally. Sole of propodus armed with 13-15 basal spines of uniform size. Terminal claw long, auxiliary claws minute.

Genital apertures: in the males these appear to be restricted to a slight spur on distal ventral surface of second coxae of fourth legs. In females genital apertures are found on a slight mound on ventro-distal surface of all legs.

Measurements (in mm.) male paratype: Length (tip proboscis to tip 4th lateral process) 2·1, width across 2nd lateral processes 1·1, length chelifore scape 0·74, greatest width of proboscis 0·26. Third leg: 1st coxa 0·35, 2nd coxa 0·94, 3rd coxa 0·94, femur 1·67, 1st tibia 1·58, 2nd tibia 1·36, tarsus 0·1, propodus 0·71, claw 0·45.

REMARKS

This species is very close to *A. longiceps* Stock, 1954 (= *A. longicollis* Williams, 1941 preocc.) from Lindeman Island, Whitsunday Passage, Queensland. *A. simplex* differs from *A. longiceps* in the following respects: the lateral processes are not as widely spaced; the third joint of the oviger is relatively longer in *A. simplex;* the tarsus is without the long spine shown in Williams's figure; the basal spines of the propodus are uniform in size in *A. simplex,* not decreasing markedly towards the distal end as in *A. longiceps;* the femur and first tibia of *A. simplex* lack the spinous terminal processes of *A. longiceps.*

Anoplodactylus evansi n. sp.

Figs. 26 A—G

MATERIAL

2 ovigerous males (1 is the holotype), 1 female (allotype), between tidemarks, Shark Island, Port Jackson, N.S.W., coll. B. Dew, Jan., 1952. A.M. P.12129.

1 female, Shelly Beach, Yamba, N.S.W., coll. A. Cameron, Feb. 22, 1940, A.M. P.11268.

1 female, Port Arthur, Tasmania, coll. E. Mawle. A.M. P.13657.

1 female, Port Jackson, N.S.W., A.M. G.5774.

1 male, Shell Harbour, N.S.W., between tidemarks, coll. G. McAndrew Dec., 1925. A.M. P.13658.

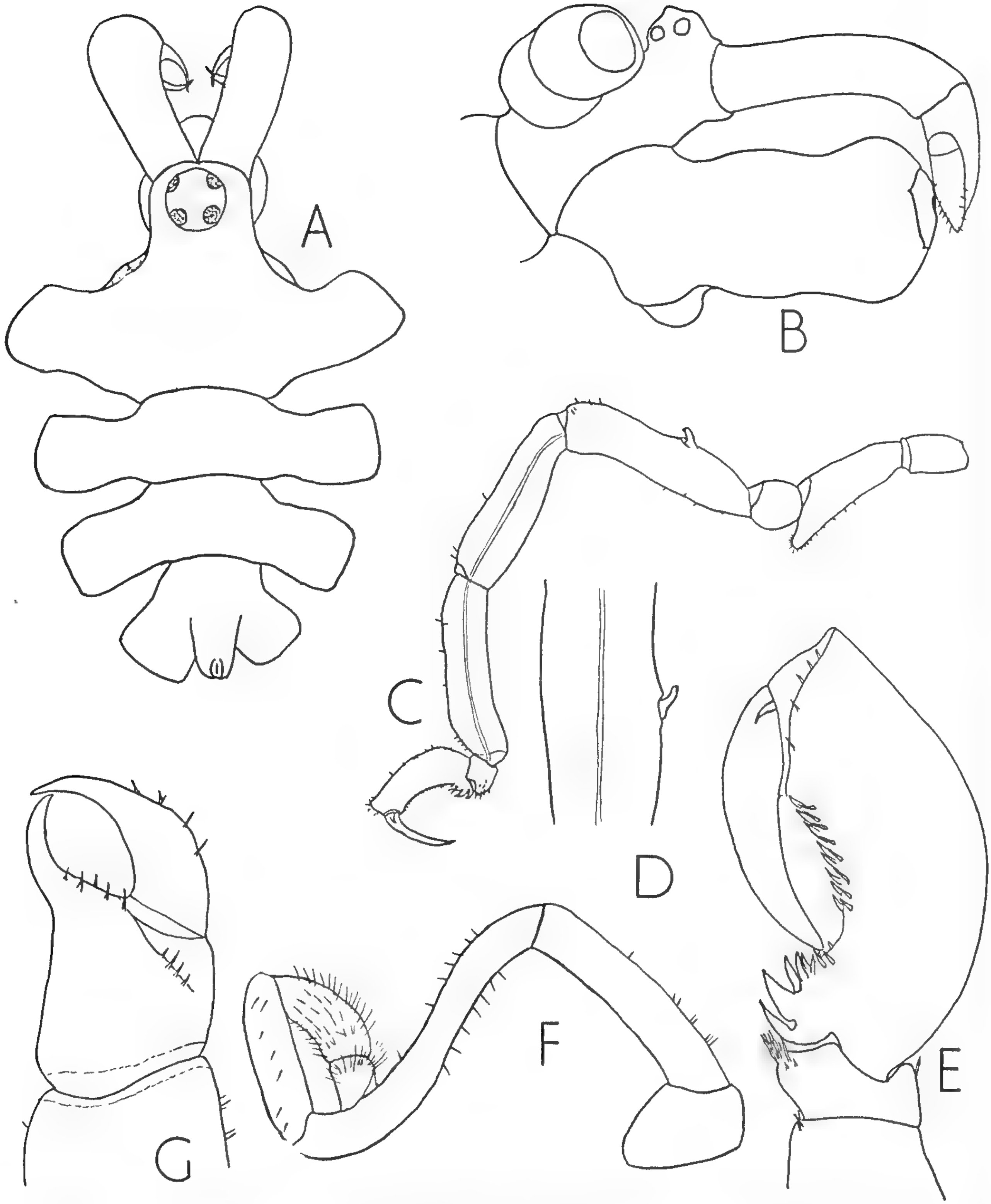

Fig. 26.—A-G, *Anoplodactylus evansi.* A, dorsal view of male; B, cephalic region of female; C, third leg of male; D, femoral cement gland; E, male propodus; F, male oviger; G, male chela.

DESCRIPTION

Trunk stout, compact, well segmented, smooth, without spines, lateral processes separated distally by about half their own width. Cephalon well developed, neck region short.

Ocular tubercle fairly low, obtusely pointed, eyes well pigmented.

Abdomen about same height as ocular tubercle, pointed upwards at an angle of 60 degrees. Anus terminal.

Proboscis stout, triquetrous, with a swelling at the mid point, and inflated distally, terminal portion truncated. In the female there is a marked bilobed eminence on ventral surface of proboscis about one-third of the distance from ventral insertion of proboscis.

Chelifore scape one-jointed simple, with a few very small spinules, fingers of chela almost as long as palm, curved, tips cross when closed, inner margins of fingers entire, central portion of outer margin of dactylus with a few setae; four setae near basal portion of inner margin of immovable finger.

Palps absent in both sexes.

Ovigers (male only) six-jointed, sigmoid third joint the longest. Joints 2, 3 and 4 armed with short sparse setae; fifth and proximal half of sixth joints with fairly dense investiture of setae, all of which are directed backwards.

Legs stout, femur the longest joint. Second coxae of third and fourth legs of male bear a large terminal ventral process beset with short setae, and bearing the genital apertures. In female similar, but rather shorter processes present on all legs; those on first and second legs much shorter. Femoral cement glands of male have a single short tubular duct inserted at two-fifths of femoral length. Tarsus short bearing only simple spinules. Propodus with heel bearing two stout spines and a number of finer ones; basal spines of two types, a median row of large regular ones, and on distal half of sole a lateral row of finer spines. Terminal claw strong, auxiliaries weak.

Measurements (in mm.) holotype male: Length (anterior margin of cephalon to tip 4th lateral process) 3·33, width 2nd lateral processes 2·77, length chelifore scape 1.11, length proboscis 1·94, greatest width proboscis 0·88. Third leg: 1st coxa 0·95, 2nd coxa 1·47, 3rd coxa 0·7, femur 2·9, 1st tibia 2·53, 2nd tibia 2·47, tarsus 0·41, propodus 1·5, claw 0·82.

REMARKS

Despite the confused state of the taxonomy of the *Anoplodactylus-Phoxichilidium-Halosoma* group of genera and the large number of species involved there seems no doubt that *A. evansi* is in fact new. In the form of the trunk *A. evansi* most closely resembles *Phoxichilidium capense* Flynn, but differs from that species chiefly in lacking the peculiar outgrowths of the body wall between the first lateral processes and the insertion of the proboscis, in the possession of bilobed eminences on the ventral surface of the female proboscis, and in the presence of spines on the chelifores.

This species is named for Dr. J. W. Evans, Director of the Australian Museum.

Anoplodactylus spec. A.

Figs. 27 A—D

MATERIAL

1 female, Burning Palms Beach, Port Hacking, N.S.W., coll. G. P. Whitley, Feb. 11 1934. A.M. P.10506 (part).

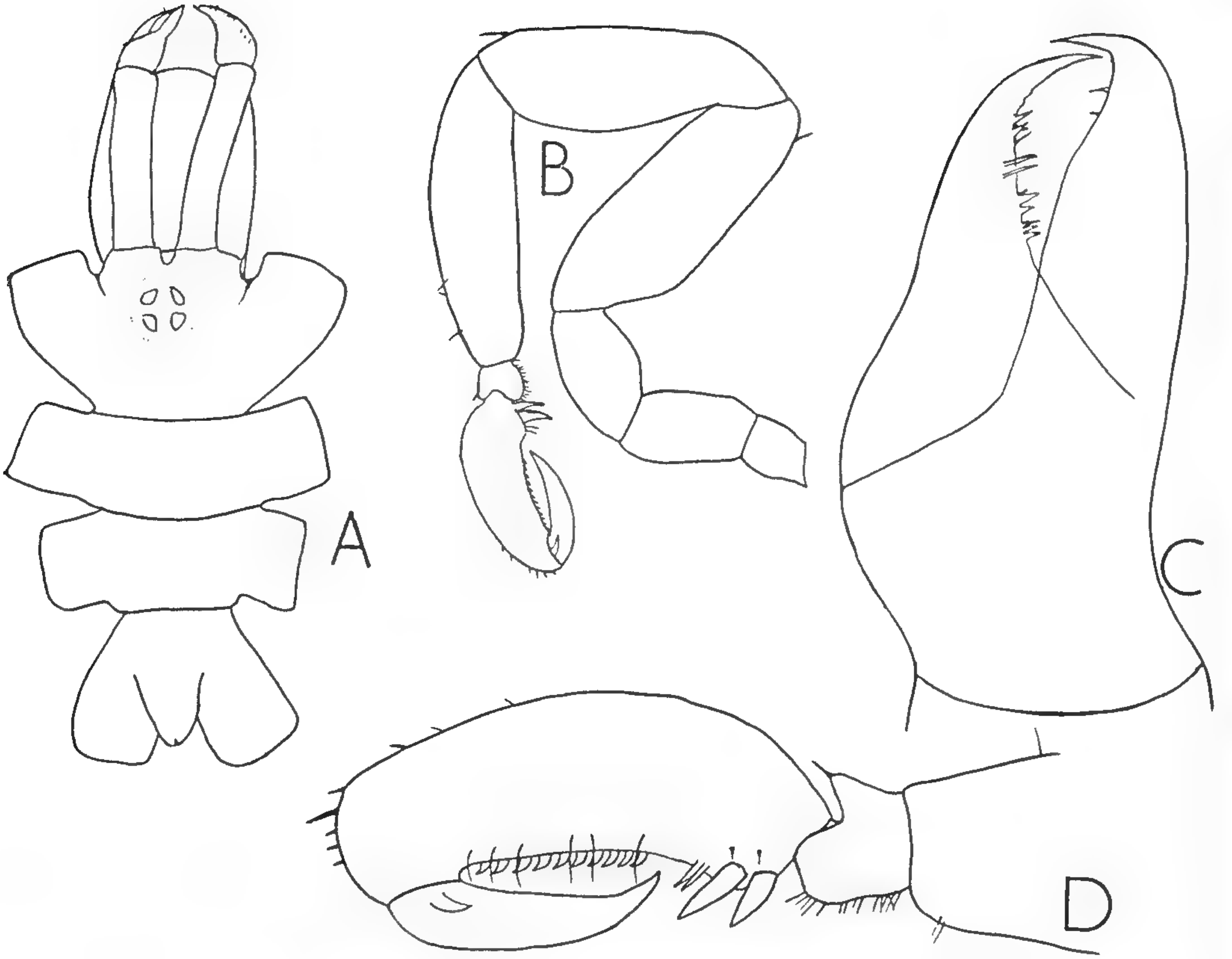

Fig. 27.—A-D, *Anoplodactylus*, spec. A, female. A, dorsal view of trunk; B, third leg; C, chela; D, propodus.

DESCRIPTION

Trunk robust, compact, smooth, lateral processes separated distally by less than their own width.

Proboscis short, cylindrical, rounded at tip, width slightly more than half length, no ventral processes; carried horizontally and anteriorly.

Ocular tubercle low, broad, rather flattened above; four well pigmented eyes present.

Abdomen short, thick at base but narrowing toward rounded tip, set at about 15° from the horizontal.

Chelifore scape one-jointed, without conspicuous setae; chela palm shorter than fingers which are sharply bent near tips. Dactylus a little shorter than immovable finger and bearing a few irregular denticulations.

Palps and ovigers lacking.

Third leg robust, coxae rather narrow by comparison with the long joints. Third coxa the longest coxal joint. Long joints subequal. Propodus with slight heel bearing two stout spines and two more slender ones. Spines on sole smaller than on heel but regular in size. Claw a little more than half as long as propodus. Auxiliary claws minute.

Measurements (in mm.): length trunk (anterior margin of cephalon to tip abdomen) 1·33, length cephalon 0·47, width across second lateral processes 0·6, length chelifore scape 0·47, length proboscis 0·66, greatest width proboscis 0·43, length abdomen 0·17. Third leg: 1st coxa 0·22, 2nd coxa 0·44, 3rd coxa 0·51, femur 1·13, 1st tibia 1·12, 2nd tibia 1·19, tarsus 0·15, propodus 0·68, claw 0·41.

REMARKS

This species is distinct from all others recorded from this region, but in the absence of males it cannot be decided with any certainty whether it is new to science or not. I therefore refrain from naming this species.

Anoplodactylus spec. B

Figs. 28 A—F

MATERIAL

1 female, Port Darwin, North Australia, A.M. P.6833.

DESCRIPTION

Trunk moderately robust, smooth, intersegmental lines distinct. Lateral processes short, without tubercles or spines, separated by about their own width.

Ocular tubercle low, rounded-conical above; eyes four, well pigmented.

Proboscis cylindrical with slight constriction at two-thirds of its length; tip rounded, with callosities on the ventral surface (fig. 28D).

Palps and *ovigers* lacking.

Third leg moderately robust, all joints with some spines, second coxa with a marked genital process. Femur the longest joint, but not markedly longer than tibiae. Femur with a marked spine-bearing distal dorsal process. Tarsus short. Propodus with pronounced heel bearing three large spines, sole with nine spines. Claw strong, five-eights as long as propodus; auxiliary claws minute. Genital pores present on the ventrodistral extremity of all second coxae.

Measurements (in mm.): total length (anterior margin of cephalon to tip fourth lateral processes) 2·0, length cephalon 0·8, width across second lateral processes 0·87, length proboscis 1·07, greatest width proboscis 0·4, length chelifore scape 0·73. Third leg: 1st coxa 0·27, 2nd coxa 0·82, 3rd coxa 0·5, femur 2·09, 1st tibia 1·73, 2nd tibia 1·64, tarsus 0·14, propodus 0·73, claw 0·47.

REMARKS

In the absence of males which are of great systematic importance in this genus, I have refrained from naming this species. Of the known Australian forms it approaches most closely to *A. longiceps* Stock, 1954 (= *A. longicollis* Williams, 1941 preocc.), but is readily distinguished from that species by the low ocular tubercle and the three large spines on the heel of the propodus (*A. longiceps* has one very large and two slender spines).

Key to Australian species of **Anoplodactylus**

1. Ocular tubercle more than twice as high as diameter at base — 2

   Ocular tubercle less than twice as high as diameter at base — 3

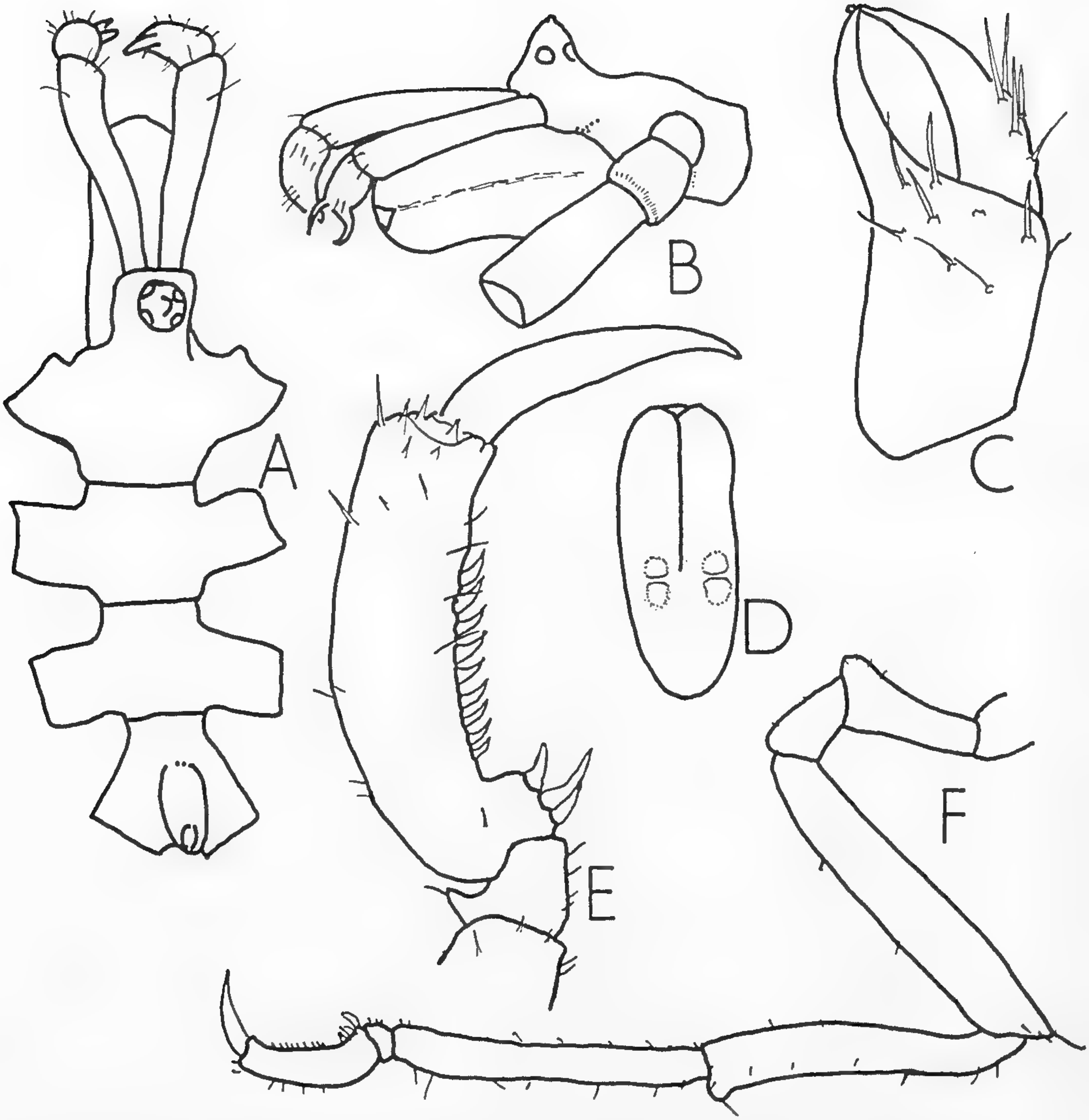

Fig. 28.—A-F, *Anoplodactylus*, spec. B, female. A, dorsal view of trunk; B, lateral view of cephalic region; C, chela; D, ventral view of proboscis; E, propodus; F, third leg.

2. Ocular tubercle rounded above, eyes near apex; chelifore scape with five or more long setae near middle . *A. tubiferus*

   Ocular tubercle pointed distally, eyes set below mid-point; chelifore scape without long setae near middle . *A. longiceps*

3. Lateral processes separated by their own width throughout length; females with four ventral eminences on proboscis . *A.* spec. B.

   Lateral processes not separated by more than half their own width; females with two or no ventral eminences on proboscis . 4

4. Legs with lateral darker stripe, females with pair of ventral eminences on proboscis. *A. evansi*

   Legs without lateral darker stripe, females without ventral eminences on proboscis 5

5. Second and third lateral processes in contact, or almost so throughout their length (fig. 24A). *A. haswelli*

Second and third lateral processes diverging throughout their length (fig. 27 A). *A.* spec. A.

Family **AMMOTHEIDAE** Dohrn, 1881

Genus **Ammothea** Leach, 1814

Ammothea australiensis Flynn

Figs. 29 A—G

Ammothea australiensis Flynn, 1919b: 95-99, pl. XIV, figs. 4-6.

Achelia flynni Marcus, 1940: 84, 124.

Ammothea australiensis Stock, 1954: 105. ——Stock, 1956a: 43.

MATERIAL

1 male, Port Jackson, N.S.W., A.M. P.13660.

1 juvenile, Green Point, Port Jackson, N.S.W., coll. T. Iredale and G. P. Whitley, Jan. 15, 1934. A.M. P.13661.

1 male, 4 females, Port Jackson, N.S.W. A.M. P.13659.

REMARKS

This species has not been recorded since it was described by Flynn. As Stock (1956a) pointed out, the two most northern members of this genus, usually regarded as strictly Antarctic in distribution, have long been overlooked by Pycnogonid workers. *A. australiensis* Flynn, known only from New South Wales, and *A. magniceps* Thomson, from several localities in the South Island of New Zealand, provide the exceptions to the otherwise Antarctic distribution of the genus.

Flynn's only specimen was rather badly damaged. The following points complete his otherwise satisfactory description:—

Chelifore (adult male) short, scape of one joint with two setae at distal end, chela reduced to a globose knob. Juvenile scape of one joint, smooth; chela almost as long as scape; fingers of chela equal in length to palm. Fingers bowed; immovable finger slightly longer than dactylus.

Palps: relative lengths of joints as stated by Flynn, but joints 5-9 bear a number of spines and setae along their ventral margins.

Oviger (male) 10-jointed, the joints having the following lengths (in mm.) 1—0·17, 2—0·67, 3—0·47, 4—0·56, 5—0·56, 6—0·39, 7—0·19, 8—0·11, 9—0·09, 10—0·06. The seventh joint has a lateral swelling beset with strong setae. Joints 8-10 bear a few small pinnate oviger spines according to formula 2 : 3 : 3. There is no terminal claw.

Genital apertures in male appear to be restricted to second coxae of third and fourth pairs of legs. There is no genital eminence.

Cement glands appear as low mounds about three-quarters of the distance along the dorsal surface of femur.

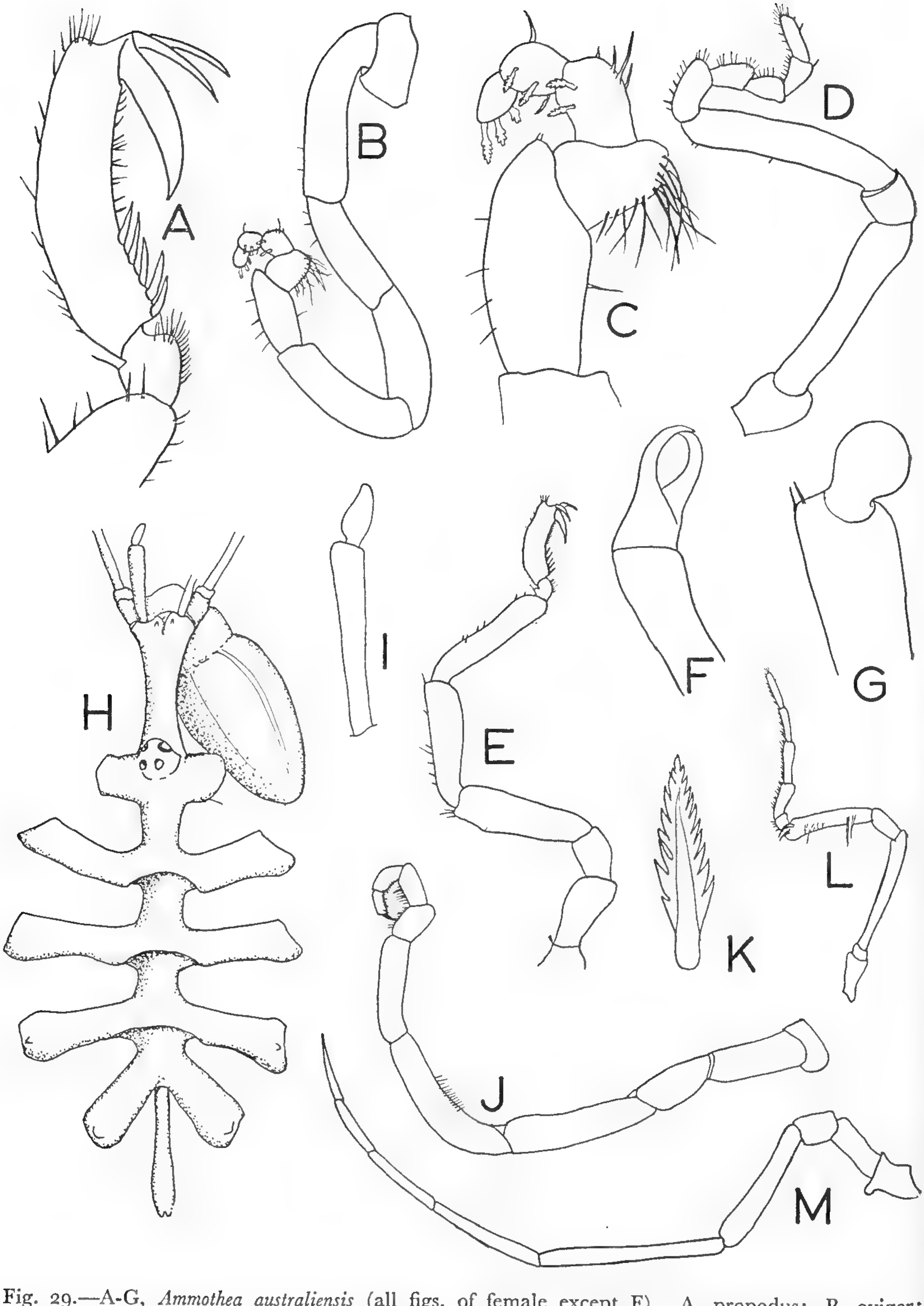

Fig. 29.—A-G, *Ammothea australiensis* (all figs. of female except F). A, propodus; B, oviger; C, terminal oviger joints; D, palp; E, third leg; F, chela of juvenile; G, female chelifore. H-M, *Ascorhynchus longicollis* female. H, dorsal view of trunk; I, chelifore; J, oviger; K, oviger spine; L, palp; M, third leg.

Stock (1956a: 43) says, "Ich habe sogar lange gezweifelt, ob *A. australiensis* nicht mit *magniceps* identisch sein sollte. *A. australiensis* hat aber längere Nebenkralle und spitzere Rückenbuckel."

Since I have adequate material of *A. magniceps* available I have compared the two species. The following table of differences establishes the validity of the two species:—

A. australiensis	*A. magniceps*
Total length adult male, tip cephalon to tip 4th lateral process, 1·6 mm.	Total length adult male, tip cephalon to tip 4th lateral process, 3·0 mm.
Dorsal eminences high, pointed.	Dorsal eminences in form of low ridges.
Scattered spines on dorso-lateral extremities of lateral processes and 1st coxae.	No spines on lateral processes or 1st coxae.
Ratio of length auxiliary claw: terminal claw: propodus 1: 1·43: 2·75.	Ratio of length of auxiliary claw: terminal claw: propodus 1: 1·66: 3·44.

Genus **Achelia** Hodge, 1864

Achelia assimilis (Haswell)

Ammothea assimilis Haswell, 1884: 1026-1027, pl. LIV, figs. 5-9. ——Whitelegge, 1889: 233. ——Loman, 1908: 59-60.

Achelia assimilis Bouvier, 1913: 140. ——Flynn, 1920: 87-90, pl. XXI, figs. 22-26. ——(small form) ? Stock, 1954: 97-99, fig. 45. ——Stock, 1956a: 42-43.

MATERIAL

1 female, Port Jackson, N.S.W., A.M. P.13662.

1 chelate juvenile, Clark Island, Port Jackson, N.S.W., timber test pile, coll. F. McNeill and M. Ward, Oct. 18, 1927. A.M. P.13663.

REMARKS

Though the present material differs in a few minor respects from that described by Flynn and Stock, I do not doubt that it is to be identified with this species. The differences that exist between the female specimen before me and the previously published descriptions are: the lateral processes bear 3 spine-bearing tubercles, not 2 as in Stock's material; the compound spines on the oviger segments 6-10 have the formula 1 : 1 : 1 : 1 : 2 instead of 1 : 1 : 2 : 1 : 2, and the abdomen has a slight constriction in the proximal half, but Flynn and Stock figure it as slightly dilated in this region. The movable finger of the chela is represented by a rudimentary knob.

The variation which appears to exist in the representatives of this species in New Zealand waters, as mentioned by Stock (1954 and 1956a), will be dealt with in some detail in a future paper on the Pycnogonida of New Zealand and will not be discussed here.

Achelia variabilis Stock.

Achelia variabilis Stock, 1954: 100-105, figs. 47, 48.

MATERIAL

1 male, trawled 5 miles off Green Cape, N.S.W., 81 metres, coll. K. Moller, May, 1930. A.M. P.13664.

1 ovigerous male, about seven miles north-east of Cape Pillar, Tasmania, 90-108 metres clinging to sponge. Trawled F.I.S. "Endeavour", July 25, 1914. A.M. P.13665.

REMARKS

These two specimens fit Stock's figures and descriptions, except that the tubercles shown on the anterior margin of the cephalon on either side of the ocular tubercle in his figure 47a are not present. This species is otherwise only known from a locality in 65 fathoms near the Three Kings Island, New Zealand.

Genus **Tanystylum** Miers in Wilson, 1878

Tanystylum orbiculare Wilson, 1878

Literature and synonymy Stock, 1954.

MATERIAL

1 female from shoreline cave, Narooma, N.S.W., amongst growths in rock pool, coll. Miss E. Pope, July 15, 1949. A.M. P.13666.

REMARKS

Previously known in Australia from one male taken in the intertidal zone of Sydney Harbour (Stock, 1954: 145), but like the earlier recorder I am restricted by the limited material available in giving any critical evaluation of the recording of this species, widespread elsewhere, from Australian waters.

Genus **Ascorhynchus** G. O. Sars, 1877

Ascorhynchus longicollis (Haswell)

Figs. 29 H—M

Ammothea longicollis Haswell, 1884: 1028-9, pl. 56. figs. 1-4. ——Whitelegge, 1889: 223.

Ascorhynchus longicollis Loman, 1908: 32. ——Flynn, 1920: 81-83, pl. XXI, figs. 16-17.

Eurydyce longicollis Thompson, 1909: 533.

MATERIAL

1 ovigerous male, Gunnamatta Bay, Port Hacking, N.S.W., on tuft of seaweed, coll. E. Pope, Nov. 11, 1946. A.M. P.13667.

REMARKS

This appears to be the first record of this species having been taken since Haswell's description. From Flynn's comments (1920) it seems that the present specimen may be the first complete male to be examined. From it the following points emerge: the eyes appear to be normally pigmented, and not unpigmented as recorded previously; the palps are much more hirsute than earlier descriptions indicate; the fifth joint bears a number of spines arranged in three groups as indicated in fig. 29L, and joints 6-10 have a dense fringe of hairs on the ventral margin. The male oviger consists of 10 joints, of which the fourth and fifth joints are the longest

and about equal. The fifth joint bears on its inner margin a row of glandular (?) hairs or spines. Joints 7-10 bear pinnate spines arranged in three ranks, and disposed according to the approximate formula 45 : 33 : 26 : 25. I cannot be certain that these counts are correct. A terminal claw is present.

The legs are quite without spines or setae. I am unable to find any trace of the setae shown at the distal ends of the first tibia and propodus in Flynn's figure. Genital appertures occur on the second coxae of the second, third and fourth pairs of legs.

The differences between this specimen and previous descriptions may be sexual in character.

Ascorhynchus minutum Hoek

Ascorhynchus minutus Hoek, 1881: 55-57, pl. VI, figs. 10-16. ——Loman, 1908: 33.

Ascorhynchus auchenicus Calman, 1922: 199-203 (part).

Ascorhynchus minutum Stock, 1954: 121-124, figs. 57 d-h.

MATERIAL

6 ovigerous males, 1 female, Station 28, "Thetis" Expedition, 4-6½ miles off Manning River, N.S.W., 40-42 metres. A.M. P.13696.

2 females off Eden, N.S.W., 30 metres, Oct. 8, 1943; pres. K. Sheard, C.S.I.R.O., Div. of Fisheries. A.M. P.11530.

2 males, Station 37 "Thetis" Expedition 2-2½ miles off Botany Bay, N.S.W., 92-98 metres. A.M. P.13697.

2 juveniles, 5 miles east of Port Hacking, N.S.W., 100 metres, July 24, 1943; pres. K. Sheard, C.S.I.R.O., Div. of Fisheries. A.M. P.11527 (pt).

1 ovigerous male, 5 miles off Green Cape, 83 metres, coll. K. Moller, May, 1930. A.M. P.13698.

2 females, 4 miles off Eden, N.S.W., in silt, 70 metres; pres. K. Sheard, C.S.I.R.O. Division of Fisheries, Oct. 8, 1943. A.M. P.13699.

1 female, 12 miles north-east Bustard Head, near Pt. Curtis, Queensland, "8 fathoms patch" (from coral reef), Sept. 5, 1946. Pres. H. S. Hynd. A.M. P.12211.

REMARKS

I have compared these specimens with the types in the British Museum and they do not differ in any important respect.

Ascorhynchus compactum n. sp.

Figs. 30 A—H

MATERIAL

3 males (one is the holotype), Port Jackson, N.S.W., A.M. P.13668, P.13669.

5 females (one is the allotype) 2 males, 2 juveniles, Port Jackson, N.S.W., A.M. P.13670.

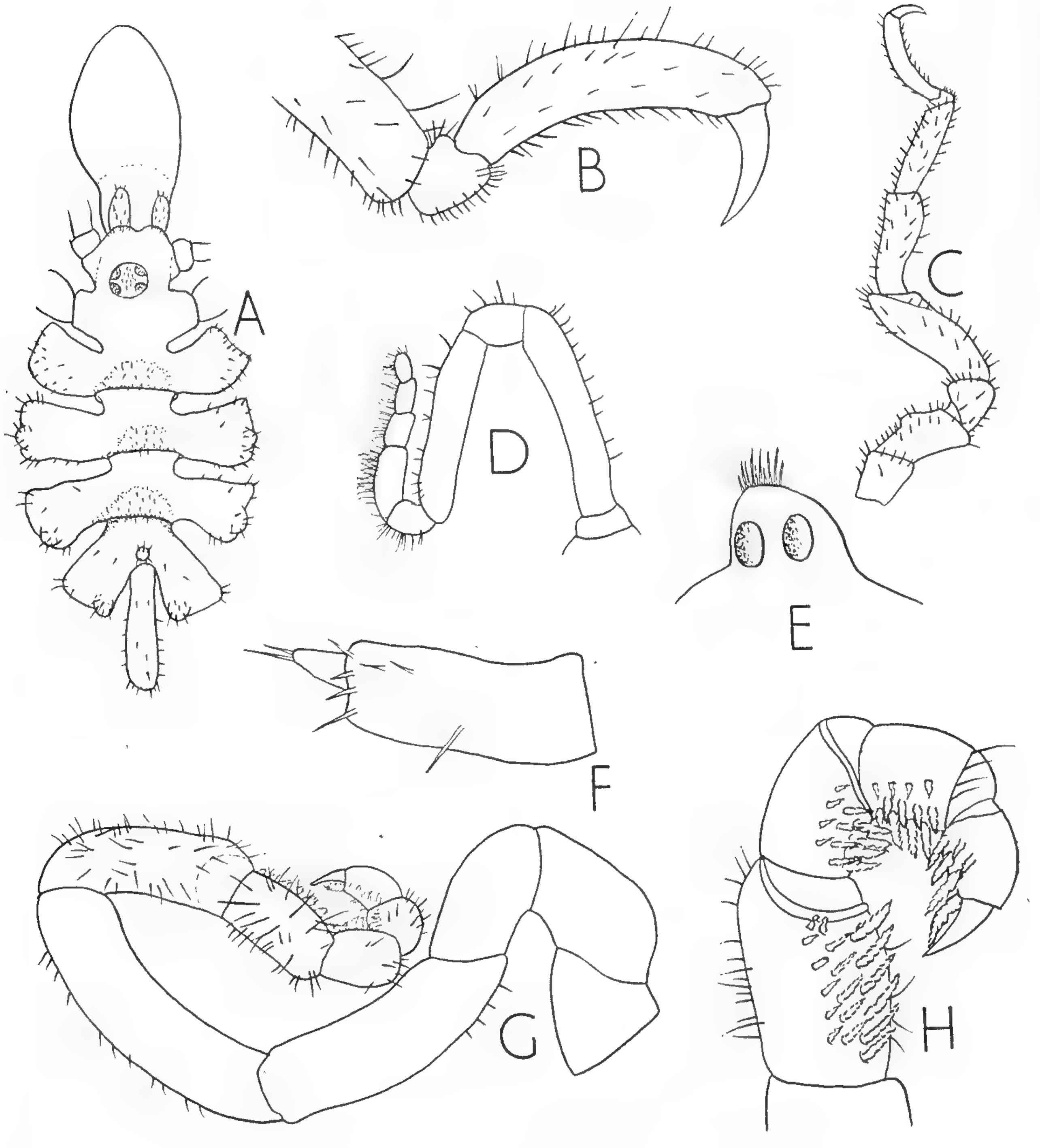

Fig. 30.—A-H, *Ascorhynchus compactum* male. A, dorsal view of trunk; B, propodus; C, third leg; D, palp; E, lateral view of ocular tubercle; F, chelifore; G, oviger; H, tip of oviger.

2 females on rocks near high tide mark, Burning Palms Beach, south of Port Hacking, N.S.W., coll. G. P. Whitley, Feb. 11, 1934. A.M. P.10506 (part).

1 male, 1 female, inside Fossil Island, Eagle Hawk Neck, Tasmania, between tide marks, coll. Prof. T. Flynn, Jan., 1928. A.M. P.13700.

DESCRIPTION

Trunk elongate oval in outline, compact to very compact; lateral processes touching or separated by about half their own width. Trunk distinctly segmented.

spinose; cephalon well developed; a short distance in front of first lateral processes arise the "cervical processes" which articulate with bases of ovigers. In some specimens these are very close to the first lateral processes, but in others there is a distinct gap between them. Cephalon slightly expanded anterior to ocular tubercle and provides articular processes for palps. At anterior extremity of cephalon a pair of spinose swellings overly the chelifore bases. Distal portions of lateral processes bear a number of setae. In dorsal midline are four setose eminences; the first three are broader than long, but the fourth, just anterior to origin of abdomen, is a cylindrical tubercle.

Ocular tubercle situated immediately in front of cervical processes; it rises steeply on anterior face and slopes away more gently behind. Tubercle capped with a number of short setae. Four well-pigmented eyes present.

Abdomen long, reaching to tip of second coxa, horizontal in position, setose. Anus almost ventral.

Proboscis pyriform, typical of genus.

Chelifores: scape of one joint with knobs as rudiments of chelae; both scape and knob spinose.

Palps nine-jointed, second and fourth joints longest; all joints with setae, last five joints with a dense ventral fringe of setae.

Oviger 10-jointed with a terminal claw, setae numerous on joints 5-9, sparse on joints 4 and 10, and absent from joints 1-3. Joints 7-10 bear numerous denticulate spines arranged in three rows as in figure 30H. Lengths of male oviger joints are 1—0·3, 2—0·48, 3—0·42, 4—0·65, 5—0·83, 6—0·77, 7—0·3, 8—0·18, 9—0·15, 10—0·14, claw 0·095 mm.

Leg setose; femur the longest joint, bears a large distal process, tibiae subequal; propodus without heel; basal spines weak, claw about half length of propodus, auxiliary claws lacking.

Genital Apertures on slight swellings on ventral surfaces of second coxae of third and fourth legs of male, and on second coxae of all legs in female.

Measurements (in mm.), holotype (male): total length (tip proboscis to fourth lateral processes) 4·23, width 2nd lateral processes 1·73, length abdomen 0·67, length chelifore scape 0·29, length proboscis 1·46, width proboscis 0·73. Third leg: 1st coxa 0·35, 2nd coxa 0·58, 3rd coxa 0·38, femur 1·06, 1st tibia 0·86, 2nd tibia 0·82, tarsus 0·15, propodus 0·77, claw 0·35.

REMARKS

Although superficially similar to *Ascorhynchus melwardi* Flynn, 1929, from Albany Passage, near Cape York, Queensland, this species is quite distinct, differing markedly in size, spination of the lateral processes, the dorsal eminences, the ocular tubercle, the shape and relative lengths of the leg joints and the details of the oviger.

Genus **Ammothella** Verrill, 1900

Ammothella biunguiculata australiensis Williams

Figs. 31 E—H

Ammothella biunguiculata var. *australiensis* Williams 1940: 197-200, figs. 1-3.

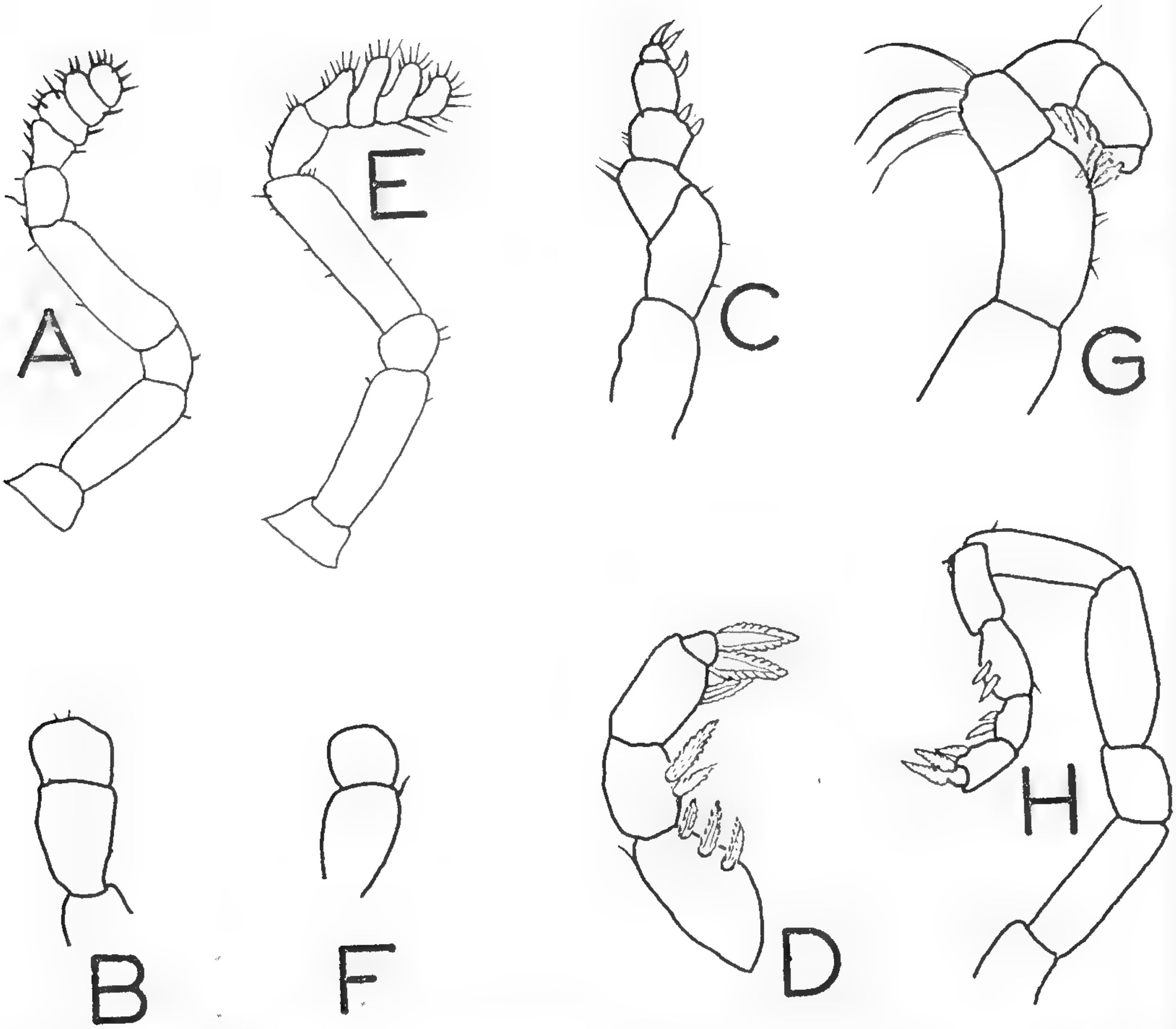

Fig. 31.—A-D, *Ammothella biunguiculata biunguiculata.* E-H, *A. biunguiculata australiensis.* A and E, palps; B and F, male chelifores; C and G, tips of male ovigers; D and H, tips of female ovigers.

MATERIAL

1 male, 1 female, Bottle and Glass Rocks, Port Jackson, N.S.W., Jan. 15, 1934, coll. G. P. Whitley. A.M. P.10472.

1 ovigerous male, Bottle and Glass Rocks, Port Jackson, N.S.W., under stone, Oct. 22, 1930, coll. T. Iredale. A.M. P.13673.

1 larvigerous male, Bottle and Glass Rocks, Port Jackson, N.S.W., Jan. 20, 1934, coll. G. P. Whitley and T. Iredale. A.M. P.13674.

1 damaged female, Bottle and Glass Rocks, Port Jackson, N.S.W., March, 1926, coll. M. Ward. A.M. P.8617.

1 damaged female, Long Reef, Collaroy, on coast north of Port Jackson, N.S.W., Sept. 22, 1930, coll. T. Iredale and G. P. Whitley. A.M. P.13675.

2 females, 2 males, Shark Island, Port Jackson, N.S.W., A.M. P.3253.

1 male, 14 miles off Bateman's Bay, N.S.W., 135 metres, trawled, coll. K. Moller, trawler "Durraween". A.M. P.13671.

1 male, Bottle and Glass Rocks, Port Jackson, N.S.W., between tide marks, coll. F. A. McNeill, Oct. 12, 1927. A.M. P.13672.

REMARKS

The adequate material available leaves little doubt that this form is identical with William's var. *australiensis*. The status of the "varieties" (= subspp.) of *A. biunguiculata* is not very satisfactory. Hedgepeth (1941: 259) considers Hall's (1911) var. *californica* to be identical with *A. biunguiculata* Dohrn (1881), and discontinued the use of the varietal name. Williams (1940) also doubted that the Californian form should have been given varietal recognition. Since this time Hilton (1942a) has described *A. biunguiculata fusca* from Hawaii. It is impossible to tell from Hilton's figures and description whether *fusca* is really distinct from *australiensis* or the other forms. His description is without detailed figures of the palps, chelifores and legs. The figure of the male oviger is wretched. The measurements of *A. b. australiensis* and *A. b. fusca* are about the same, and judging from the descriptions the chief differences appear to lie in the setae on the legs, but since Hilton uses the terms "long", "really long" and "very long" without reference to any other structure, and omits such setae from his figures entirely, one cannot at present sort out this tangle. Hairiness varies considerably in *A. b. australiensis*, and Hilton does not discuss the features in which *A. b. fusca* differs from the previously known subspecies.

I have carefully compared the Australian material before me with two males and a female of *A. biunguiculata* from Los Angeles, California (coll. and det. J. W. Hedgepeth) and find that the termino-lateral apophyses of joints 6-9 of the palps are more produced in the Australian material than in the Californian. The terminal joint of the chelifore is almost spherical in *A. b. australiensis* and rather squarish in the Californian specimens. The male ovigers of the two forms differ in spination and the relative lengths of the joints. In *A. b. australiensis* the 4th and 5th joints are proportionately much longer than in the Californian material. The 7th joint in *A. b. australiensis* bears four setae which are longer than the width of the joint, but the Californian specimens bear only two such setae. The female ovigers appear to be very similar. Colour (in alcohol) varies in *A. b. australiensis* from pale straw colour through bright orange to brown.

Measurements of male ovigers (in mm.).

Joint	1	2	3	4	5	6	7	8	9	10
Californian specimen ..	0·22	0·42	0·217	0·367	0·361	0·230	0·132	0·096	0·090	0·041
Australian specimen ..	0·18	0·42	0·241	0·482	0·482	0·217	0·156	0·090	0·108	0·030

Measurements of female oviger

Joint	1	2	3	4	5	6	7	8	9	10
Californian specimen ..	0·06	0·30	0·20	0·33	0·29	0·17	0·14	0·09	0·12	0·04
Australian specimen ..	0·06	0·29	0·14	0·30	0·29	0·18	0·12	0·09	0·10	0·03

Measurements of male palps

Joint	1	2	3	4	5	5-9
Californian specimen ..	0·12	0·34	0·09	0·43	0·14	0·31
Australian specimen ..	0·12	0·36	0·12	0·45	0·18	0·33

Ammothella stocki n. sp.

Figs. 32 A—J

MATERIAL

1 male (holotype), Grain Jetty, Darling Harbour, Port Jackson, N.S.W., amongst marine growth on oregon test piece of timber; coll. F. A. McNeill, Oct. 11, 1927. A.M. P.13676.

DESCRIPTION

Trunk segmented, oval in outline, lateral processes moderately stout, separated distally by not more than half their diameter, ends of lateral processes bearing a number of spines and a dorsal, median, round-tipped papilla. Near posterior border of median part of second trunk segment are two erect blunt papillae. Cervical processes, on which ovigers articulate arise at level of ocular tubercle, and just anterior to first lateral processes. Neck region short. Two spurs present behind palp bases. A transverse furrow marks off anterior and posterior regions of first trunk segment.

Ocular tubercle anterior to first lateral processes, tall (height three times the basal diameter), directed slightly forward, eyes near tip, four, well pigmented.

Abdomen curved, arising from dorsal surface of last trunk segment, proximal half directed upwards and backwards, distal half directed slightly downwards. Abdomen armed with two types of spines; simple spines arranged (in dorsal view) as a lateral pair in mid-region and a dorso-lateral subterminal pair, and the more obvious large, stout, hollow, cylindrical spines arranged in a group of four at about one-third of abdomen length and a further pair at two-thirds of abdomen length. Similar abdominal spines are known in *A. appendiculata* Dohrn, 1881 and *A. indica* Stock, 1954.

Proboscis twice as long as wide, narrowest at base, widest near middle and narrowing again towards tip. Tip rather flattened. Length slightly more than twice greatest diameter.

Chelifores with two-jointed scape, armed with simple and hollow spines. As spination differs between left and right scapes in the holotype this is not discussed in detail. Second joint bears a circlet of spines at distal end surrounding an invagination from which projects the knob-like remnant of the chela. Terminal joint bears a single simple spine.

Palps nine-jointed; first joint short, second and fourth joints longest. Joints 1-4 with a few simple spines, but joints 5-9 with conspicuous ventral fringe of setae. No hollow spines on palps. Length of joints (in mm.): 1—0·09 (approx.), 2—0·36, 3—0·09, 4—0·41, 5—0·15, 6—0·18, 7—0·09, 8—0·08, 9—0·17.

Oviger 10-jointed, first joint wide and short, joints 4 and 5 equal and the longest joints, joints 9 and 10 equal and the shortest. Joint 8 bears five large spines with wide bases and entire margins, and also a few simple setae; joint 9 with one serrated

and two simple spines, and the tenth joint bears 3 pinnate spines. Length of joints (in mm.): 1—0·17, 2—0·37, 3—0·27, 4—0·425, 5—0·425, 6—0·16, 7—0·13, 8—0·09, 9—0·09, 10—0·02.

Third leg stout, spinose, with hollow spines on coxae 1 and 2, femur and both tibiae; all joints with some simple spines, especially tibiae. Femur very stout.

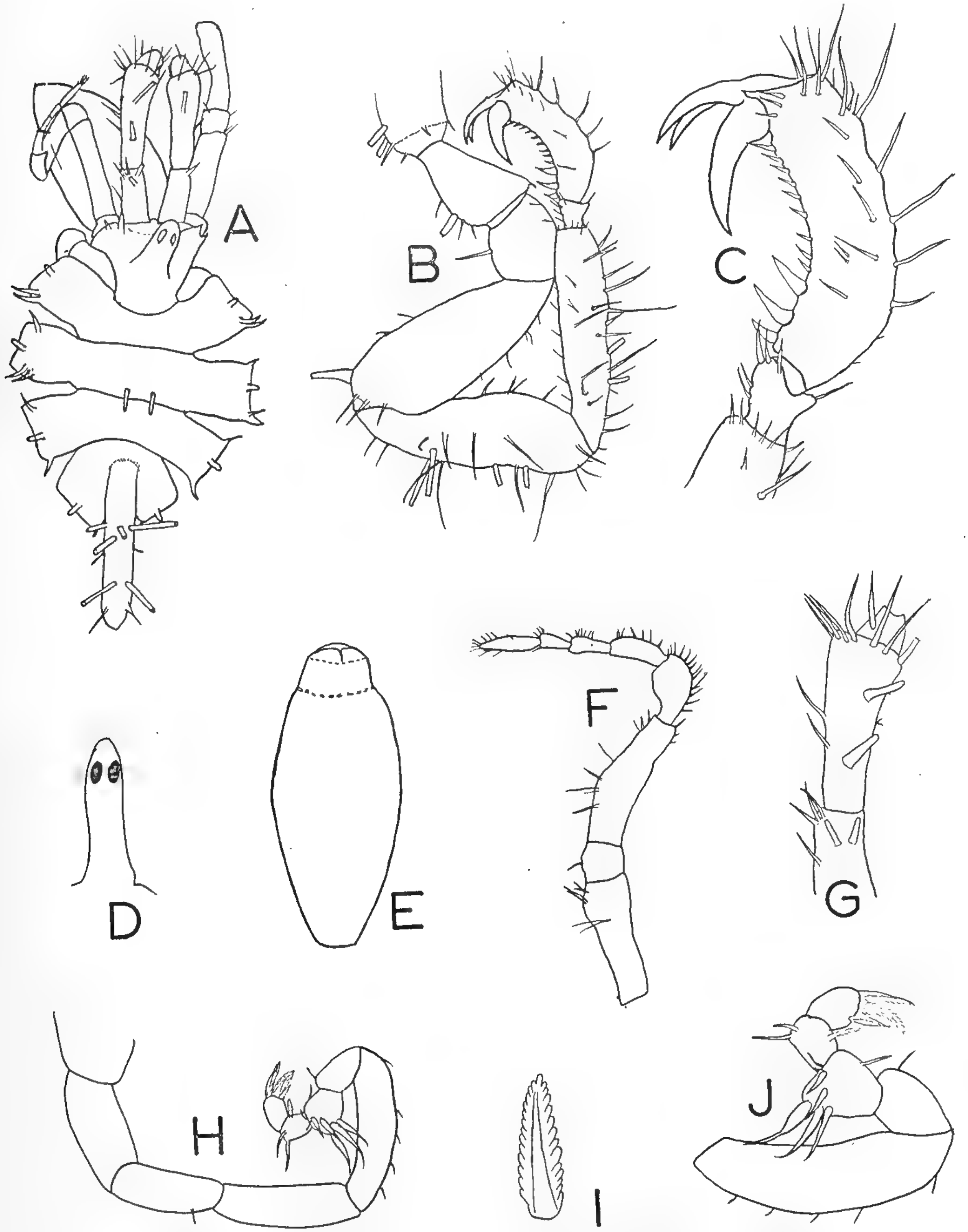

Fig. 32.—A-J, *Ammothella stocki* holotype male. A, dorsal view of trunk; B, third leg; C, propodus; D, lateral view of ocular tubercle; E, proboscis; F, palp; G, chelifore; H, oviger.

Propodus curved, sole with three large basal spines proximally and nine smaller ones distally. Claw strong, almost half as long as propodus; auxiliary claws three-quarters as long as main claw.

Genital apertures on very slight eminences on second coxae of third and fourth legs.

Measurements (in mm.), holotype (male): Length (anterior margin of cephalon to tip of fourth lateral processes) 1·1, width across second lateral processes 0·83, length proboscis 0·83, length of abdomen 0·59, length chelifore scape 0·55. Third leg; 1st coxa 0·33, 2nd coxa 0·41, 3rd coxa 0·33, femur 0·91, 1st tibia 0·92, 2nd tibia 0·87, tarsus 0·106, propodus 0·55, claw 0·24, auxiliary claws 0·17.

REMARKS

I have named this species in honour of Dr. Jan H. Stock, of the Zoological Museum, Amsterdam, who has done much to further knowledge of the Pycnogonida of the world.

A. stocki resembles *A. indica* Stock, 1954, in the armature of the abdomen, but differs in other important respects (oviger, leg and chelifores). The Australian species of the genus are readily separated on the relative sizes of the main and auxiliary claws; in *A. biunguiculata* the main claw is virtually lacking, in *A. thetidis* n. sp. the auxiliary claws are the longest, and in *A. stocki* the main claw is longer than the auxiliaries.

Ammothella thetidis n. sp.

Figs. 33 A—G, 34 A—F

MATERIAL

27 males, many ovigerous (of which one is the holotype), 33 females (one is the allotype), 18 immature, station 57 " Thetis " Expedition, 3½-4 miles off Wata Mooli, near Botany Bay, N.S.W., 107-115 metres, dredged. A.M. P.13677, P.13678, P.13679.

8 males, 8 females, Station 37 " Thetis " Expedition, 2-2½ miles off Botany Bay, N.S.W., 93-97 metres, dredged. A.M. P.13680.

1 ovigerous male, Station 35, " Thetis " Expedition, 1¼-2 miles off Port Hacking, N.S.W., 40-70 metres, dredged. A.M. P.13681.

DESCRIPTION

Trunk clearly segmented, oval in outline, integument smooth, pale straw coloured (in alcohol); lateral processes slender, twice as long as broad, separated by more than their own width distally. Dorsum ornamented in mid-line by two tall, round-tipped tubercles on the posterior margins of segments 2 and 3, similar in height and shape to ocular tubercle. Distal ends of lateral processes each armed with a single tall round-tipped tubercle about half as high as median tubercles.

Ocular tubercle tall, slender, situated in centre of dorsal surface of cephalon anterior to first lateral processes. I am unable to find any trace of eyes.

Proboscis with a short basal stalk, ovate beyond stalk and with two slight callosities on ventral surface (fig. 33E).

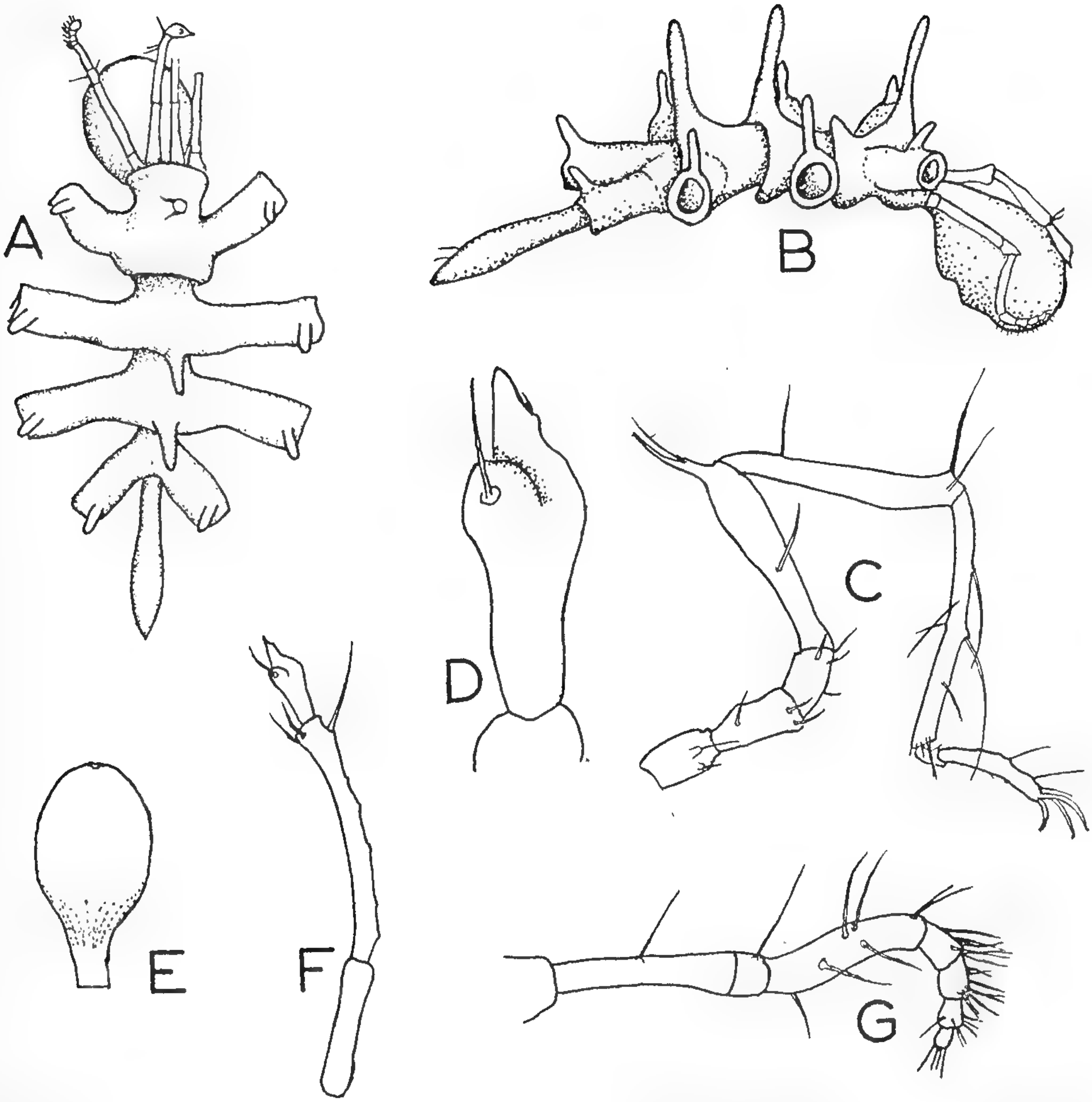

Fig. 33.—A-G, *Ammothella thetidis* male. A and B, dorsal and views of trunk; C, third leg; D, chela; E, proboscis; F, chelifore; G, palp.

Abdomen horizontal, clavate, reaching to end of second coxae of fourth legs.

Chelifores with two-jointed scape, the second joint almost twice as long as first, and bearing three spines at its distal end. Terminal joint achelate; dactylus reduced to a spine-bearing knob.

Palp eight-jointed, first joint short and wide, second the longest and bearing a single spine, third joint short, fourth almost as long as second but with more spines. Joints 5-8 short, with ventral fringe of setae.

Oviger 10-jointed, very similar in both sexes. Lengths of joints (in mm.): 0·18, 0·3, 0·215, 0·36, 0·3, 0·12, 0·1, 0·07, 0·09, 0·02. Joint 5 with a group of reversed spines near distal end. Denticulate spines on joints 9 and 10 only, but stout simple spines on joints 6 and 8.

Third leg moderately robust, all joints with a few setae, coxae 1 and 3 subequal, coxa 2 the longest coxal joint; femur robust, thickened distally, and with a long thin

tubular cement gland on dorsal extremity in males. Tibia 1 longer than femur, and equal to tibia 2; tibia 2 with a few long spines; tarsus short; propodus moderately long, straight along sole with one or two long spines on dorsal surface. Basal spines differ with sexes, being very sparse in males and more numerous in females, but small in both sexes. Terminal claw two-thirds as long as auxiliary claws which are large and well-developed.

Measurements (in mm.), male paratype: Length (anterior margin of cephalon to tip of abdomen) 1·6, length cephalon 0·32, length proboscis 0·75, greatest width of proboscis 0·32, width across second lateral process 0·65, length chelifore scape (both joints) 0·6, length abdomen 0·65. Third leg: 1st coxa 0·03, 2nd coxa 0·37, 3rd coxa 0·25, femur 0·7, 1st tibia 0·99, 2nd tibia 1·0, tarsus 0·09, propodus 0·42, claw 0·12, auxiliary claw 0·180.

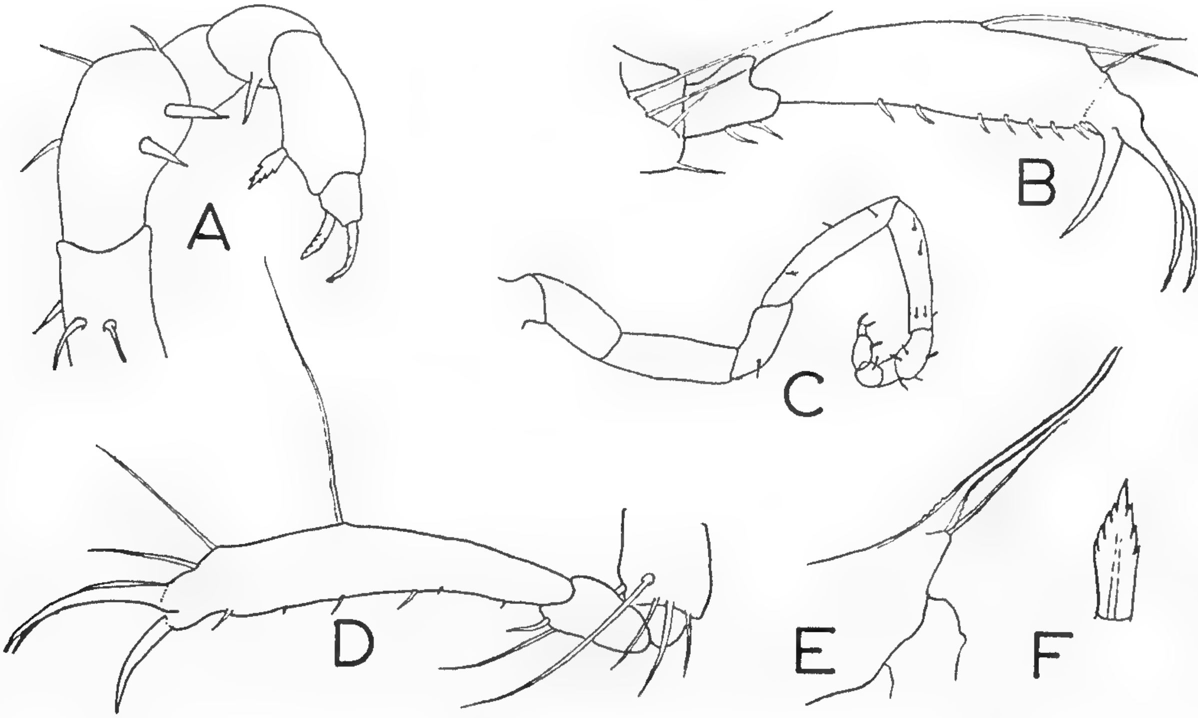

Fig. 34.—A-F, *Ammothella thetidis.* A, tip of male oviger; B, female propodus; C, male oviger; D, male propodus; E, femoral cement gland; F, oviger spine.

REMARKS

Ammothella thetidis is easily distinguished from all other species in the genus by the unique combination of characters it presents, namely, auxiliary claws longer than the main claw, two-jointed chelifore scape without tubercles, and well-developed median tubercles on the posterior margins of trunk segments two and three.

Key to the Australian species of **Ammothella**

1. Principal and auxiliary claws well developed ... 2

   Principal claw rudimentary, auxiliary claws well-developed ... *A. biunguiculata australiensis.*

2. With median dorsal tubercles on trunk segments 2 and 3; no blunt-ended spines on legs, abdomen or chelifore scapes ... *A. thetidis* n. sp.

   Without median tubercles on trunk segments; with blunt-ended spines on chelifore scape, legs and abdomen ... *A. stocki* n. sp.

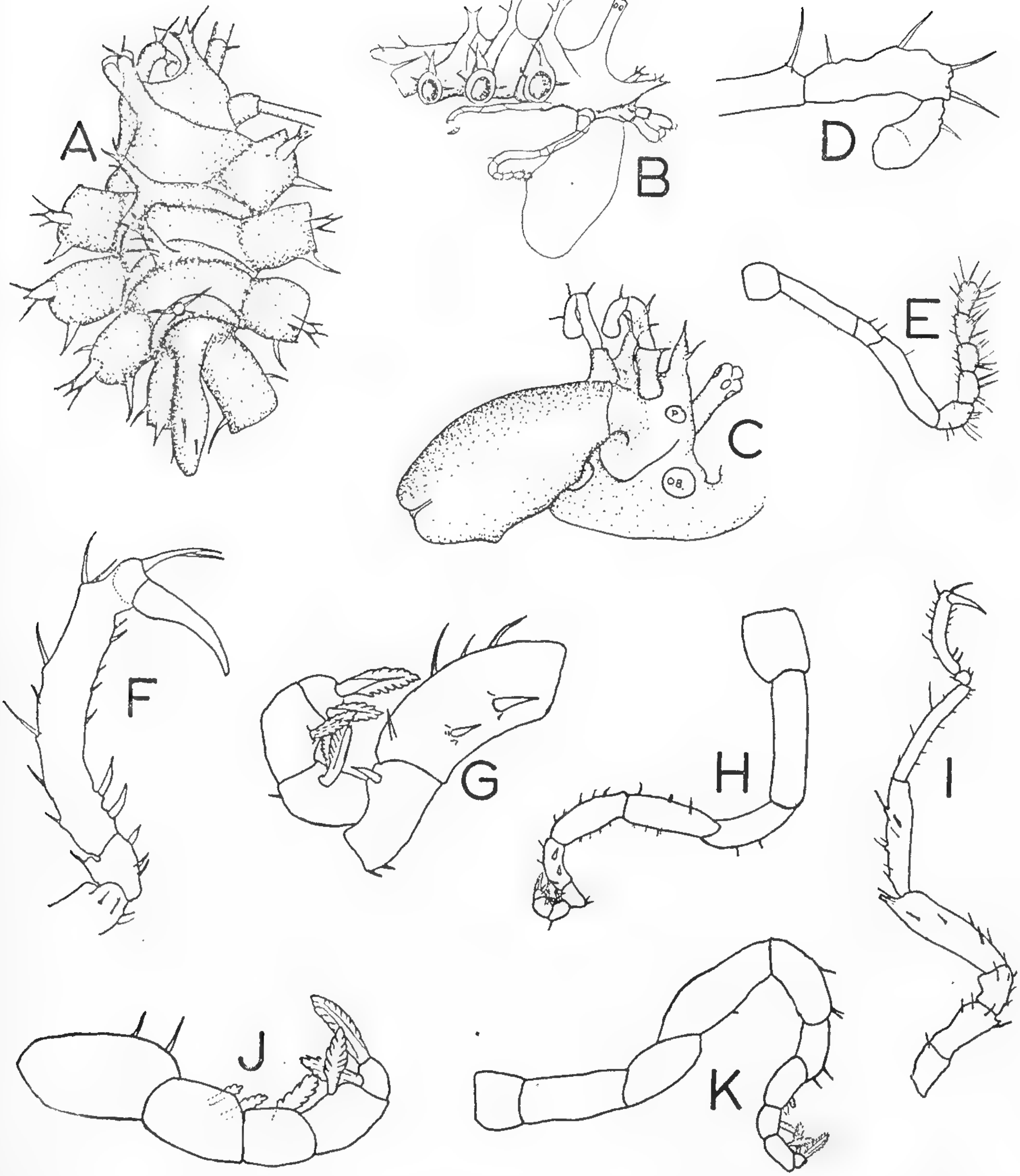

Fig. 35.—A-K, *Cilunculus australiensis;* A and B, dorsal and lateral views of trunk; C, ventro-lateral view of cephalic region (P = palp base, O.B. = oviger base); D, chelifore; E, palp; F, male propodus; G, tip of male oviger; H, male oviger; I, male third leg; J, tip of female oviger; K, female oviger.

Genus **Cilunculus** Loman, 1908

Cilunculus australiensis n. sp.

Figs. 35 A—K

MATERIAL

1 ovigerous male (holotype), 2 females (one is allotype), Station 35, " Thetis " Expedition, 1¼-2 miles off Port Hacking, N.S.W., 40-70 metres; dredged. A.M. P.13682, P.13683, P.13684.

1 ovigerous male, 1 female, 1 juvenile, Station 57, "Thetis" Expedition, $3\frac{1}{4}$-4 miles off Wata Mooli, near Botany Bay, N.S.W., dredged. 96-107 metres. A.M. P.13685.

1 ovigerous male, 1 female, Station 37 "Thetis" Expedition, 2-$2\frac{1}{2}$ miles off Botany Bay, N.S.W., 90-94 metres; dredged. A.M. P.13686.

DESCRIPTION

Trunk compact, distinctly segmented; oval in outline; cephalon much longer than succeeding segments, greatly expanded anteriorly to form a hood over bases of chelifores and proboscis. Anterior margin of cephalon produced into two columnar projections which project forwards over chelifores. Each such projection bears three or four spines or setae. Sides of hood provide for articulation of palps. Posterior part of dorsum of segments 1-3 marked by a transverse ridge which is surmounted by a tall spinose tubercle. Lateral processes narrowly separated at base; with simple and compound spines distally.

Ocular tubercle very tall, erect with a spreading base, appears to be divided into four at tip. Four eyes present.

Proboscis inserted and carried ventrally, pyriform, narrowest at base, with two low transverse ridges on ventral side, tip rounded.

Chelifores with a scape of two joints, the first with a single spine, the second with four; terminal joint achelate.

Palps nine-jointed, geniculate; first and third joints short, second and fourth joints longest and subequal; joints 5-9 short and setose.

Ovigers 10-jointed, inserted just anterior to first lateral processes. Female: fourth joint longest; all joints fairly straight, joints 5-6 with a few simple setae; joints 7-10 with compound spines according to formula 2 : 1 : 1 : 2. Male: second joint longest (as in other species of the genus); joints 3-6 bearing more simple setae than in female; sixth joint with two stout spines in addition to setae; compound spines on joints 8-10 according to formula 1 : 1 : 2. Measurements of oviger joints (in mm.):—

Joint	1	2	3	4	5	6	7	8	9	10
Male	0·15	0·31	0·22	0·32	0·19	0·14	0·07	0·06	0·05	0·02
Female ..	0·07	0·16	0·14	0·22	0·12	0·1	0·08	0·05	0·06	0·02

Third leg moderately robust, all joints setose; coxae 1 and 3 subequal, coxa 2 longer; femur stout, twice as long as second coxa, with distodorsal cement gland in male. Tibia 2 equal in length to femur and slightly longer than tibia 1. Tarsus short, propodus slightly curved with a number of strong dorsal spines, two strong basal spines proximally, but weaker distally. Claw strong, nearly half as long as propodus; auxiliary claws two-thirds as long as main claw.

Measurements (in mm.) of holotype male: Length (anterior margin of cephalon to tip of abdomen) 1·32, length cephalon 0·42, width across second lateral processes 0·8, length proboscis 0·67, greatest width proboscis 0·37, length abdomen 0·37, chelifore scape (both joints) 0·38, height ocular tubercle 0·37. Third leg: 1st coxa 0·21, 2nd coxa 0·35, 3rd coxa 0·18, femur 0·6, 1st tibia 0·52, 2nd tibia 0·6, tarsus 0·075, propodus 0·4, claw 0·18, auxiliary claw 0·12.

REMARKS

Cilunculus australiensis differs from all other known species of the genus in the presence of setose columnar processes on the anterior expansion of the cephalon and in the great height of the dorsal trunk tubercles. It is difficult to say to which of the known species of the genus *C. australiensis* is most closely allied; in the development of the dorsal tubercles it is approached by *C. sewelli* Calman; in the shape and position of the cement gland duct and in details of the propodus it is similar to *C. antillensis* Stock, while the processes on the anterior margin of the cephalon are most closely approached by those of *C. perspicax* Loman.

Cilunculus hirsutus n. sp.

Figs. 36 A—L

MATERIAL

5 males (one is holotype), 2 exuviae, Station 57 "Thetis" Expedition, 3½-4 miles off Wata Mooli, near Botany Bay, N.S.W., 96-107 metres; dredged. A.M. P.13687, P.13688.

DESCRIPTION

Trunk robust, oval in outline, segmented. Lateral processes separated by about three-quarters of their own width. Anterior margin of each trunk segment fits into a recess on expanded posterior face of preceding segment. Posterior margin of segments 1-3 ornamented in dorsal midline by a small blunt-ended tubercle. Lateral processes bear a number of hairs on lateral margins and dorsally a single small tubercle bearing a long hair. Cervical processes bearing ovigers situated just anterior to first lateral processes. Anterior to cervical processes cephalon expands over base of proboscis. Palps arise from posterior limit of this expansion, and chelifores from anterior limit. Antero-lateral extremities of expansion drawn out to form two spine-bearing processes, on whose vental sides the chelifores are inserted.

Ocular tubercle tall, slender above, pointed at tip, base spreading. Eyes not pigmented, appear to be four.

Proboscis with a slender proximal region, expanding gradually to attain maximum diameter at middle and tapering slightly towards tip, which is bluntly rounded. In the material examined the proboscis is either carried pointed downwards as in the figures, or horizontally against the ventral surface of the trunk.

Abdomen long, clavate, flexed slightly downwards, reaching just beyond distal end of 2nd coxae, with distinct cuticular fold at base. Spination of abdomen regular; two long setae on dorsal surface at one-third of its length, two shorter lateral setae about midway, and two lateral and two long dorsal setae at two-thirds of abdominal length. There may be two short setae beyond this point.

Chelifore scape two-jointed, basal joint short, second joint longest, beset with setae and inflated at end to form a shallow cup-like invagination in which is inserted the knob-like terminal joint. Terminal joint achelate, with a small rudiment of dactylus set in a pit (fig. 36D).

Palps nine-jointed, second joint longest, third short, fourth moderately long; joints 5-9 decreasing in size and with a ventral fringe of setae.

Oviger (male only known) 10-jointed, second joint longest (as in all other males in genus), first and third joints short, fourth and fifth of moderate length with

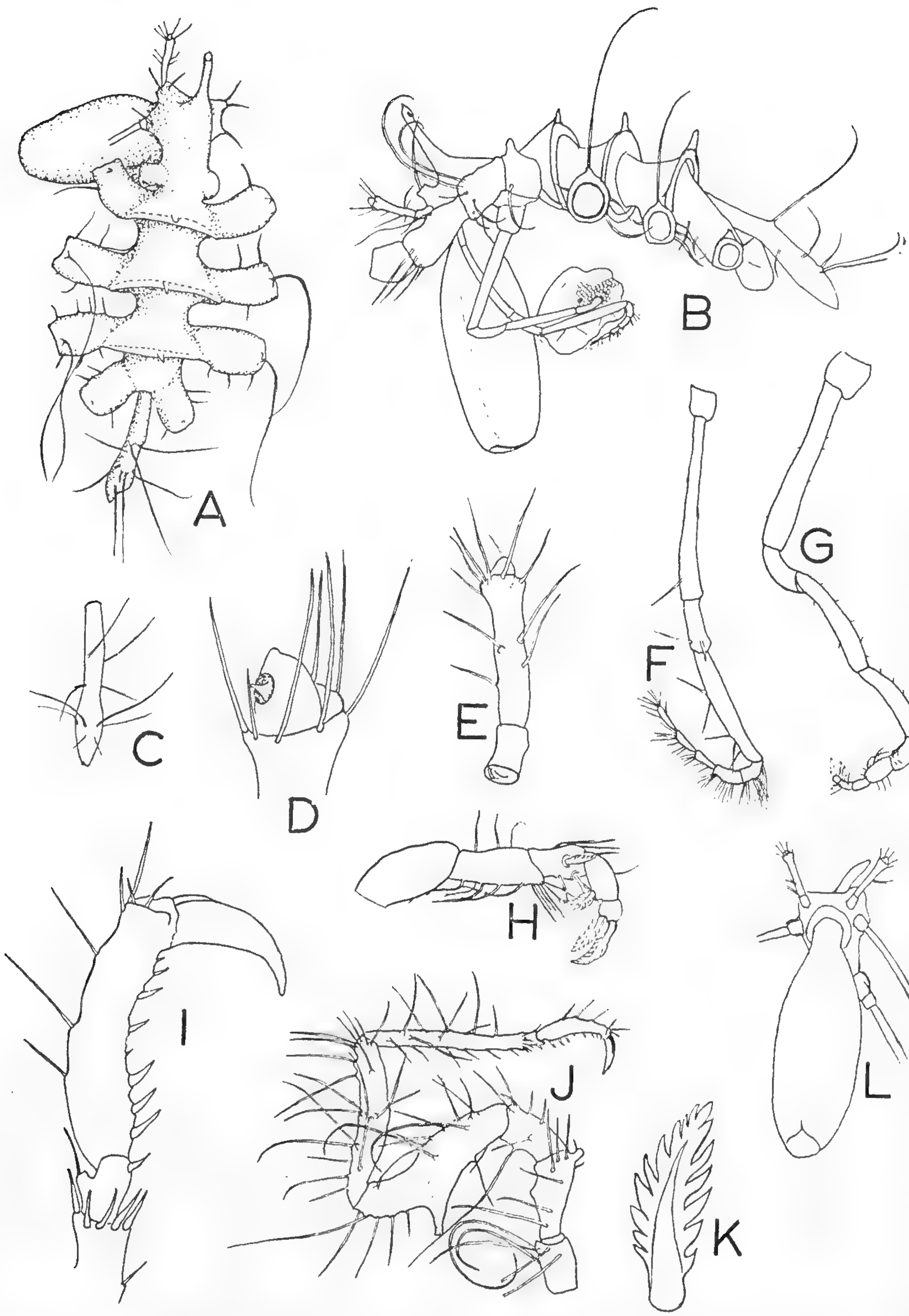

Fig. 36.—A-L, *Cilunculus hirsutus;* A and B, dorsal and lateral views of trunk; C, abdomen; D, tip of chelifore; E, chelifore; F, palp; G, male oviger; H, tip of male oviger; I, propodus; J, male third leg; K, oviger spine; L, ventral view of anterior region.

short setae. Joints 6-10 decreasing in size. Joint 7 with a number of long setae; joints 8-10 with denticulate spines according to formula 2 : 1 : 2. No terminal claw.

Third leg robust, all joints beset with long setae. First coxa shortest, second coxa longest coxal joint and bearing the genital pore on a small, rounded, genital tubercle on ventrodistal extremity. Femur robust, with a very large conspicuous tubular cement gland on dorsal surface; femur and tibiae subequal. Tarsus short, propodus robust, almost straight, with three strong basal spines proximally, remaining spines on sole weaker; claw strong, curved, half as long as propodus. Auxiliary claws weak.

Measurements (male paratype in mm.): length trunk (anterior margin of cephalon to tip of abdomen) 4·7, length cephalon 1·3, width across second lateral processes 2·55, length proboscis 2·9, greatest width proboscis 1·0, length chelifore scape (both joints) 0·8, length abdomen 1·75. Third leg: 1st coxa 0·5, 2nd coxa 0·9, 3rd coxa 0·65, femur 1·8, 1st tibia 1·72, 2nd tibia 1·6, tarsus 0·17, propodus 0·65, claw 0·37.

REMARKS

C. hirsutus is most similar to *C. frontosus* Loman, 1908, in the general form of the trunk and the setose legs. It differs however in the greater robustness of the legs, especially the femur, the antero-lateral processes of the cephalic expansion, and in the possession of three jointed chelifores. The last joints of the chelifore, especially the reduced dactylus, is reminiscent of *Ascorhynchus parvituberculatum* Stock, 1953. In both species the chela is set in the excavated tip of the preceding joint, and the dactylus is short, peg-like, and set in a pit (Stock 1953: 301 calls it the " immovable finger ").

The distribution of members of this genus is of interest:

C. armatus (Böhm, 1879) Japan.

C. antillensis Stock, 1955, St. Croix, Virgin Islands.

C. australiensis n. sp. New South Wales, Australia.

C. hirsutus n. sp. New South Wales, Australia.

C. frontosus Loman, 1908, north of the Celebes Islands.

C. perspicax Loman, 1908, north of the Celebes Islands.

C. sewelli Calman, 1938 (= *Ammothella gigas* Fage, 1956 n. syn.) off Zanzibar, and new record: in 100 fathoms just south of Mayor Island, New Zealand.

Family **COLOSSENDEIDAE** Hoek, 1881

Genus **Colossendeis** Jarzynsky, 1870

Colossendeis macerrima Wilson, 1881

For chief literature see Stock, 1953.

MATERIAL

1 female, Great Australian Bight, long. 126° 45′, 190-320 fathoms, coll. F.I.S. " Endeavour ", April 4, 1913. A.M. E.3742.

REMARKS

This species was first recorded in the Australian region by Hoek (1881) under the name *C. gigas-leptorhynchus* from Lat. 50° 1′ S., long. 123° 4′ E. The species is very widespread and is now regarded as a cosmopolitan deep-water form.

Family **PYCNOGONIDAE** Wilson, 1880

Genus **Pycnogonum** Brünnich, 1764

Pycnogonum torresi n. sp.

Figs. 37 A—D

MATERIAL

1 female (holotype) Murray Island, Torres Strait, 10-15 metres, coll. C. Hedley and A. R. McCullock, 1907. A.M. P.13689.

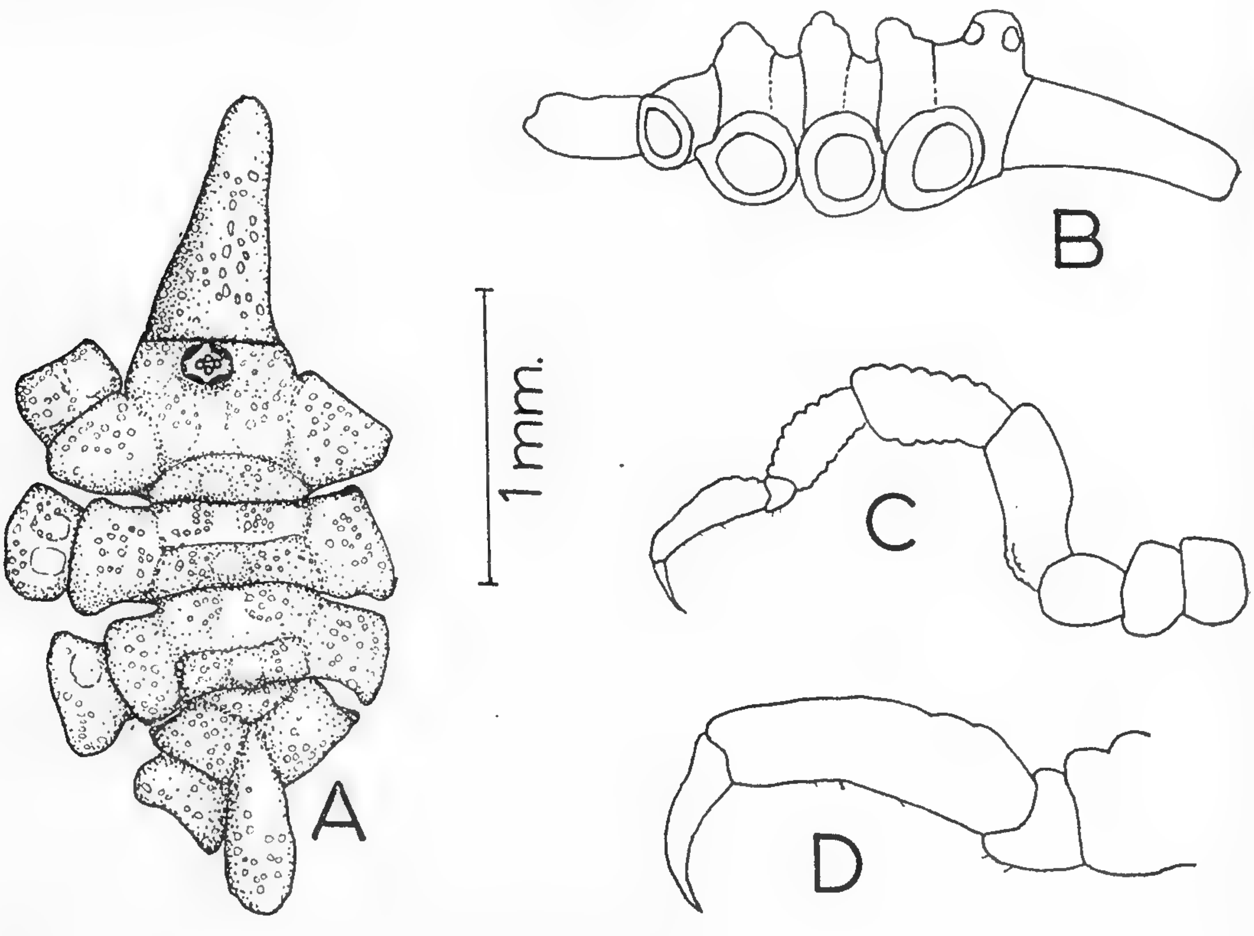

Fig. 37.—A-D, *Pycnogonum torresi* female. A and B, dorsal and lateral views of trunk; C, third leg; D, propodus.

DESCRIPTION

Trunk: integument strongly granular with signs of incipient reticulation; colour (in alcohol) brown. Trunk stout, oval in outline, no fusion of segments. Segments 1-3 with lateral processes marked off from central area by antero-posteriorly directed furrows. Central region of segments further divided by a transverse furrow into a fairly smooth anterior part and a posterior part which is thrown up into a round-topped ridge that is surmounted centrally by a round-topped tubercle. Median

tubercle lacking on fourth trunk segment. Lateral processes very close or touching. Posterior borders of fourth pair of lateral processes fused to the basal part of abdomen.

Ocular tubercle placed near anterior margin of cephalon; about as high as wide, rounded on top; four eyes, lightly pigmented.

Proboscis conical, tapering towards tip; with a slight downward flexure, about as long as trunk segments 2-4.

Abdomen horizontal, thick, rounded at tip, reaching to posterior margin of second coxae of fourth legs.

Oviger unknown. (Only one female specimen known).

Third leg moderately stout, integument somewhat nodulous; femur and first tibia subequal and the longest joints; propodus slightly arcuate; basal spines very few and small. Terminal claw almost half as long as propodus; auxiliary claws absent.

Genital pores (female) on dorsal surface of second coxae of all legs.

Measurements (in mm.), female holotype: total length 2·85, length cephalon 0·55, width second lateral processes 1·1, length proboscis 1·07, width proboscis at base 0·52, length abdomen 0·5. Third leg: 1st coxa 0·18, 2nd coxa 0·27, 3rd coxa 0·27, femur 0·6, 1st tibia 0·57, 2nd tibia 0·39, tarsus 0·13, propodus 0·46, claw 0·21.

REMARKS

This species shows considerable resemblance at first sight to *P. tenue* Slater, from Japanese waters, in the shape of the proboscis, the surface of the integument, and the shape of the legs. It differs, however, in being only about half the size of that species (measurements of *P. tenue* are given by Stock, 1954, and Utinomi, 1955), and also in the absence of the first post-ocular tubercle and the tubercle of the fourth trunk segment. Hedgepeth, 1949, and Stock, 1954, both found genital pores on the last pair of legs only in *P. tenue*, whereas in *P. torresi* they are present on all legs.

Pycnogonum tuberculatum n. sp.

Figs. 38 A—D

MATERIAL

3 females (one of which is the holotype), trawled west-south-west of Gabo Island, N.S.W., 130 metres, coll. K. Moller, trawler "Durraween", Dec., 1929. A.M. P.13690, P.13691.

2 females off Gabo Island, N.S.W., 148 metres, coll. F.I.S. "Endeavour", Nov. 18, 1913. A.M. E.4649 (part).

1 female, East of Babel Island (eastern slopes of Bass Strait), 125 metres, coll. F.I.S. "Endeavour", May 28, 1914. A.M. E.5111 (part).

1 female, 25 miles east of Babel Island, Bass Strait, 119 metres, trawled F.I.S. "Endeavour", March 28, 1914. A.M. P.13692.

1 female trawled 14 miles off Batemans Bay, N.S.W., 140 metres, coll. K. Moller, trawler "Durraween". A.M. P.13693.

1 female off Botany Bay to Wata Mooli, N.S.W., about 90 metres, collected from nets (in port) off trawler "Thistle", coll. C. W. Mulvey, Nov. 19, 1924. A.M. P.7579.

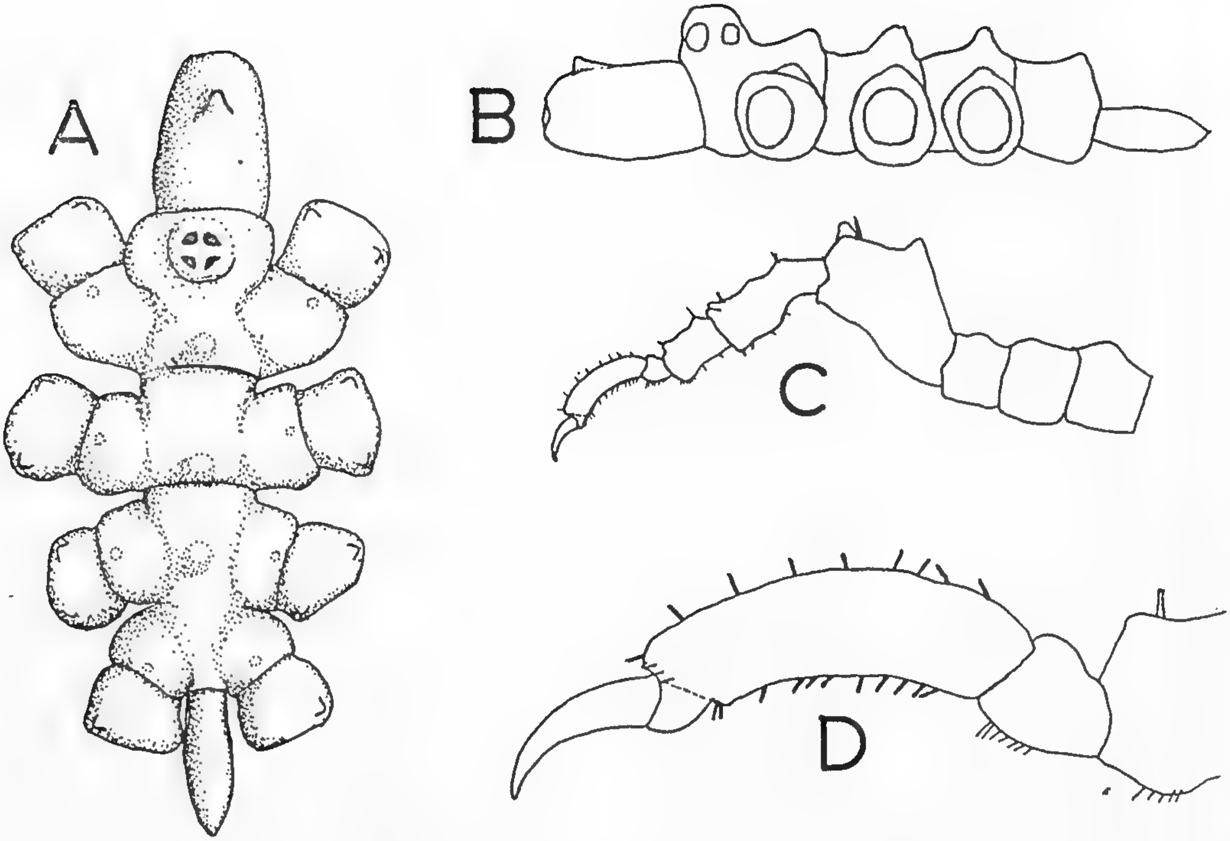

Fig. 38.—A-D, *Pycnogonum tuberculatum* female. A and B, dorsal and lateral views of trunk; C, third leg; D, propodus.

DESCRIPTION

Trunk: integument granular, colour (in alcohol) reddish-brown; trunk stout, heavy, width across second lateral processes roughly equal to half length of trunk segments. First and second trunk segments clearly marked off from each other, and from posterior segments by intersegmental lines. Third and fourth segments fused. Segments 1-3 each bears a low, round tipped eminence in mid-line near posterior margin. Lateral processes slightly separated at base, more widely separated distally. Lateral processes 3 and 4 almost touching. A small tubercle is present distally on dorsal surface of each lateral process.

Ocular tubercle placed at anterior margin of cephalon, flattened on top, almost as high as basal diameter. Four eyes.

Proboscis cylindrical, tapering slightly towards the tip; tip rounded. Length (in dorsal view) about equal to that of abdomen. At two-thirds of length from base on dorsal surface is a single median tubercle, rising steeply on the anterior face and sloping gently downwards posteriorly (this is not very obvious in dorsal view).

Abdomen horizontal, reaching to a point half way along third coxa; widest part at about two-thirds of its length, after this it tapers to a rounded tip. Anus terminal.

Palps, chelifores and *ovigers* absent. (Only females known).

Third leg stout, first and second coxae subequal, third coxa smaller, femur massive, roughly triangular in outline, with a prominent dorsal tubercle. First tibia the second longest joint, wider distally than proximally. Second tibia about

half as long as first tibia. Propodus arcuate with a few weak spines; basal spines sparse, blunt-ended. Terminal claw about half as long as propodus. Auxiliary claws lacking.

Genital pores (female) on dorsal surface of second coxae of all legs.

Measurements (in mm.), female holotype given first, female paratype next in brackets: Total length 5·65 (4·85), length proboscis (ventral) 1·4 (1·3), greatest width proboscis 0·8 (0·7), width second lateral processes 1·85 (1·45), length cephalon 1·05 (0·95), length abdomen 1·0 (0·9). Third leg: 1st coxa 0·5 (0·45), 2nd coxa 0·5 (0·45), 3rd coxa 0·5 (0·45), femur 1·47 (1·2), 1st tibia 1·0 (0·8), 2nd tibia 0·5 (0·5), tarsus 0·25 (0·2), propodus 0·7 (0·5), claw 0·35 (0·3).

REMARKS

P. tuberculatum differs from the only other species of the genus known from the southern part of Australia, *P. aurilineatum* Flynn, in a number of features, its smaller size, the absence of a segmental line between trunk segments 3 and 4, and the longer abdomen, which is round-tipped in *P. tuberculatum* and square-ended and reaching only to the end of the first coxae in *P. aurilineatum*. *P. tuberculatum* resembles *P. forte* Flynn from South Africa in the partial fusion of the third and fourth trunk segments, and *P. rhinoceros* Loman in the presence of a tubercle on the proboscis, but differs from both of these species in most other features.

Key to Australian species of **Pycnogonum**

1.	Tip of abdomen squarish, truncated.	*P. aurilineatum* Flynn
	Tip of abdomen rounded	2
2.	Proboscis barrel-shaped with a small dorsal tubercle	*P. tuberculatum* n. sp.
	Proboscis conical, without a dorsal tubercle.	*P. torresi* n. sp.

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A REVISION OF THE EARTHWORM GENUS *DIGASTER*

(Megascolecidae, Oligochaeta)

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(Figs. 1-7)

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SUMMARY

The account begins with a brief review and discussion of recent trends in the systematics of the Megascolecidae.

The genus *Digaster* Perrier 1872 is revised and *Perissogaster* Fletcher 1887 is united with it. The status of the digastric genus *Didymogaster* Fletcher 1886 is discussed and reasons are given for retaining the genus although Fletcher's definition no longer merits separation from *Digaster*.

A definition of *Digaster* s. lat. is followed by a key to all constituent species and a discussion of morphology and affinities in the genus.

Descriptions of six of the eleven species of the extended genus, based on new and/or type-material, are given, together with new information from the types of *D.* (= *Perissogaster*) *nemoralis*.

INTRODUCTION

This revision of *Digaster* stems from an identification, as *D. longmani*, of giant earthworms collected in Northern New South Wales by Miss E. Pope, of the Australian Museum. Before the taxonomic section is commenced, recent trends in the systematics of the Megascolecidae, the largest family of earthworms, and the only group of earthworms native to Australia, will be outlined.

Two recent events of major importance in the taxonomy of the Megascolecidae have been reduction in number of the Megascolecid subfamilies from four to two by Lee (1959), in his monograph of the earthworm fauna of New Zealand, and the elevation of the four subfamilies to family rank by Gates (1959). These conflicting actions reflect a common disenchantment among present-day oligochaetologists with the "*Notiodrilus* theory" adhered to so closely by Michaelsen (e.g. 1909) and by Stephenson in his great monograph (1930).

Followers of the *Notiodrilus* theory strove to arrange all Megascolecidae in a family tree springing from an Acanthodriline stem genus with the morphology of the extant *Notiodrilus*. To do this, generic definitions were limited to relatively few characters, mainly setae, location of male and prostatic openings and of spermathecal pores, number of gizzards, form of prostates and andry. The shortcomings of this system have been demonstrated by Gates (1959, 1958, 1942, etc.), who campaigned for more emphasis on somatic characters such as the blood vascular system, calciferous glands and other features of the alimentary canal, and also by Lee (1959), who gave a useful review of Michaelsen's classical work leading to the delimitation of the Megascolecid subfamilies, and by Jamieson (1963). The latter paper, and that of

Gates (1942), was an attempt to elucidate the classification of *Gordiodrilus* (Ocnerodrilinae), a genus which exemplified the earlier authors' tendency to omit consideration of forms which did not conform with the accepted phylogeny and suggested the evolution of the Megascolecidae from a precursor anatomically very different from *Notiodrilus*.

In his re-classification of the Megascolecidae, Lee (1959) placed the Octochaetinae in the Acanthodrilinae and divided the Ocnerodrilinae as follows: *Quechua* (i.e., *Quechuona* Gates 1941) was placed in the Megascolecinae, because of a supposed resemblance to *Plutellus*, and the remaining genera were placed in the Acanthodrilinae; *Gordiodrilus* was not referred to any subfamily. On the present evidence the author supports Gates (1939, 1959) in retaining the Ocnerodrilinae as a distinct group, although not advocating their elevation to family rank. They form a satisfactorily homogenous and distinct group as defined by Gates (1959, p. 254) on the basis of intestinal origin and position of hearts. The restriction of hearts to segments x and xi appears to distinguish them from the Megascolecinae and Acanthodrilinae and clearly separates *Quechuona* from *Plutellus*. A consideration of the histology of the oesophageal diverticula of *Quechuona* (see Jamieson 1962, fig. 5) suggests that Ocnerodriline and Megascolecine diverticula are not always structurally homologous.

Lee (1959) extended the Megascolecinae to include all forms with the male and prostatic pores restricted to xviii, the megascolecin condition of classical terminology, and only such forms. (" Megascolecine " refers to subfamily and " megascolecin " to a condition of the male terminalia.) This represents an emphasis on the location of male terminalia relative to somatic characters which exceeds that of classical workers. Gates (1959) rejected Lee's classification for a number of reasons, notably the somatic identity of *Scolioscolides* (originally placed in the Megascolecinae, with male and prostatic pores on xviii) and the Octochaetine genus *Eutyphoeus* in which the pores lie in xvii, the microscolecin condition (Gates 1937). Similarly Jamieson (1962, p. 622) has added a new microscolecin species to the megascolecin *Quechuona* on the grounds of somatic similarity.

Gates (1959) restricted the Megascolecinae to species with racemose (i.e. *Pheretima*-type) prostate glands. *Pheretima*-type prostates develop ontogenetically by peritoneal proliferation (i.e. are mesodermal) and acquire external openings by growth outward through the body wall (Stephenson and Ram 1919); tubular prostates are epidermal invaginations (Pickford 1937). On these grounds Gates considered gradual evolution from tubular to *Pheretima*-type prostates to be unlikely. The Megascolecinae, as thus restricted, were raised to family rank because the mesodermal origin of the prostates was considered to be " an evolutionary innovation of sufficient importance to justify more than subfamily status ". Species with tubular prostates excluded from the Megascolecinae went into the Acanthodrilinae, if holonephric, and into the Octochaetinae, if meronephric, and these two subfamilies were given family status as each " seems to be entitled to the same rank as the Ocnerodrilidae ". Gates agreed with the later work of Michaelsen (1921, 1929) that the three groups showed close affinity, being roughly equivalent to the Acanthodrilidae of Michaelsen, but deferred formal taxonomic indication of this as scarcely worthwhile on present evidence.

Application of Gates' classification to Australian Megascolecids would have profound effects. *Notoscolex*, *Megascolex*, *Pheretima*, *Digaster* (including *Perissogaster*, see synonymy p. 87), *Didymogaster*, *Woodwardiella*, *Exxus* (Locality unknown, presumed by Gates (1959) to be Australian) and *Perionyx*, all genera with *Pheretima*-type prostates, would remain in the Megascolecidae, while *Diplotrema*, *Diporochaeta* and *Plutellus*, all with tubular prostates and holonephric nephridia, would go into the Acanthodrilidae.

Spenceriella and *Megascolides* would go into the Octochaetidae (a transfer effected by Gates 1940 for oriental species), a group not previously recorded from Australia but occurring in India and New Zealand.

The author agrees with Gates that certain Megascolecines show Octochaetine affinities. A survey of the endemic Australian genus *Digaster* reveals that calciferous glands, partially or wholly developed, occur in all species of the genus except *D. minor* and possibly *D. lumbricoides.* Furthermore, an examination of the literature of the Australian fauna shows that calciferous glands occur frequently in other genera, including *Megascolex*, *Notoscolex* and *Megascolides.* It is remarkable that nowhere in the account of the Megascolecinae, including sixteen genera, in Stephenson's monograph (1930) is the presence of calciferous glands, or even of intermediate structures approaching these, mentioned. On the other hand the development of "incipient" and fully formed calciferous glands in the Octochaetinae is discussed. Thus consideration of calciferous glands also suggests that the two subfamilies, as previously defined, overlap.

The question remains whether Gates' division of the Megascolecidae of Stephenson on the basis of prostate form cuts across monophyletic groups and the possibility deserves consideration that the family would be better divided on the basis of calciferous glands and other somatic characters. Gates (1958) has constructed a satisfactory key to the genera of Octochaetinae solely on the basis of the number, location and structure of calciferous glands. The existence of prostates which are intermediate between the tubular and *Pheretima* ("lobate") type reported by Sweet (1900) would, if confirmed, remove Gates' distinction between Octochaetidae and Megascolecidae. Lastly, it may be questioned whether the distinction between Acanthodrilidae and Octochaetidae according as nephridia are respectively holonephric or meronephric is valid. Holonephry appears to be ancestral to meronephry but the derivation may have occurred more than once, independently, in different lineages.

Only by continued attention to details of somatic anatomy, which has been characteristic of Gates' work, and the development of karyotypic studies, can a definitive classification of the Megascolecidae be achieved. It is the author's belief that the Australian fauna, neglected for nearly thirty years, will contribute much to attainment of this objective.

SYSTEMATICS

Genus **Digaster** Perrier

Digaster Perrier 1872, *Nouv.Arch.Mus.Paris, 8*, 1872, pp. 94-96, illus. (Type-species *Digaster lumbricoides;* Australia, some from the neighbourhood of Port Macquarie); Michaelsen 1900, Tierreich, p. 196; Stephenson 1930, The Oligochaeta, p. 839.

Digaster (part.); Beddard 1895, Monograph, p. 484 (non *Didymogaster* Fletcher 1886 *a*, *Proc.linn.Soc.N.S.W.* (2), *1*, pp. 554-559).

Perissogaster Fletcher 1887 *a*, *Proc.linn.Soc.N.S.W.* (2), *2*, pp. 383-387 (Type-species *Perissogaster excavata;* Morpeth, and Hawkesbury River District, N.S.W.); Michaelsen 1900, Tierreich, p. 198; Stephenson 1930, The Oligochaeta, pp. 839-840.

Terrestrial worms ranging from slender forms little more than an inch long to inch-thick specimens over five feet in length. Number of segments less than 100 to over 300. Pigmentation of the integument present or absent. Prostomium very variable. Setae four pairs per segment. Clitellum ring-shaped or saddle-shaped,

embracing part of the region between intersegmental furrows 11/12 and 19/20. A pair of pores, each of the united prostatic duct and vas deferens of its side, present in segment xviii. Accessory puberty papillae frequently present in the vicinity of the male field or in the forebody. Female pores paired or united, presetal in xiv. Spermathecal pores two pairs, in 7/8 and 8/9 with sometimes (intraspecific variation[1]) a third pair in 6/7. Position of the first dorsal pore variable but in most species either in 5/6 or in 11/12.

Two gizzards, in v and vi, or in vi and vii (perhaps in v and vii in the type-species); or three gizzards, in v, vi and vii; oesophagus usually highly vascularized and showing partial or complete development of calciferous glands; intestine commencing in xvii or xviii, exceptionally in xvi. Dorsal blood vessel single; last hearts in xii or rarely[2] in xiii. Nephridia meronephridia; some species with tufted enteronephric and/or exonephric nephridia formed by apposition of ducts of micromeronephridia; some species with megameronephridia posteriorly. Holandric or metandric; (always?) without testis-sacs. Prostates racemose with branched ducts within the gland. Vasa deferentia (always?) uniting entally with the prostate ducts. Spermathecae two pairs, in viii and ix, or three pairs, in vii, viii and ix, each (always?) with one or more diverticula.

Key to Species of Digaster s. lat.

1 Oesophageal gizzards three 2

Oesophageal gizzards two, with rare intraspecific variation to three 4

2. (1) Penial setae present, similar to those of *D. perrieri* (fig. 7). Male pores on slight elevations corresponding approximately to the ventral setal couples. A pair of papillae or a transverse ridge present in each of intersegmental furrows 16/17, 18/19, 19/20 and exceptionally 20/21. Spermathecae narrow cylindrical pouches with very short ducts, each with a small, lobed, knob-like diverticulum .... *D. nemoralis* Fletcher 1888.

Penial setae absent 3

3. (2) First dorsal pore in 3/4. Spermathecal pores ventral to the setal rows. Accessory genital markings absent .... *D. queenslandica* Fletcher 1888.

Dorsal pores absent or present only posteriorly. Transverse depressions, reaching laterally nearly to the lateral setal rows, present anteriorly on xviii and less apparent on xix, xx and xxi ...... *D. excavata* Fletcher 1887 *a*.

4. (1) Penial setae present 5

Penial setae absent .... 6 to 11

5. (4) Penial setae as in fig. 2 .... *D. armifera;* p. 91

Penial setae as in fig. 7 .... *D. perrieri;* p. 107

6. (4) Large or giant worms. Clitellum brownish black. Male pores each situated on a low mound of which the median border only is clearly defined. Clitellar pigmentation absent between these papillae. Furrow 18/19 slightly backwardly dislocated between the ventral setal rows. Spermathecae sac-like with two convergent ovoid elongated diverticula, or a single diverticulum, sessile on the ectal end dorsally .... *D. longmani;* p. 101

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[1] *D. longmani.* [2] *D. nemoralis* and *D. perrieri.*

7. (4) Large worms. Male genital field consisting of a pair of sucker-like depressions, or papillae, in furrow 17/18 and a similar unpaired structure on the left side in furrow 18/19, lying within a glandular area and slightly laterad of the male pores which are equatorial in xviii in the ventral setal rows. Spermathecal duct about half as long as the ampulla and mostly hidden by a large dorsal indistinctly lobed diverticulum arising towards its ectal end ....*D. lamingtonensis;* p. 98

8. (4) Small worms. Male pores equatorial on xviii in the ventral setal rows on minute papillae lying within a single lip-like ridge. A transversely oval pad with raised margins present in each of furrows 19/20, 20/21 and 21/22, reaching from the equator of the segment in front to that of the segment behind. Spermathecal ampulla spherical, almost sessile on the body wall, bearing ectally an ovoid several-chambered diverticulum................ ....*D. gayndahensis;* p. 96

9. (4) Small worms. Male pores on an oval patch on xviii in the ventral setal rows; a broad glandular patch present ventrally in xix. Spermathecae with relatively large ampulla and short duct bearing a lobed diverticulum at the ectal end; similar to those of *D. lamingtonensis* but smaller ....*D. minor;* p. 105

10. (4) Fairly large worms. Male pores on papillae in the ventral setal rows; a transverse glandular region present equatorially in each of segments xvii, xix and xx and extending laterad of the ventral setal couples. Clitellum reaching furrow 19/20. Spermathecae large and sac-like, each with a very small double diverticulum.................... *D. brunneus* Spencer 1900.

11. (4) Each male pore situated on a papilla adpressed to that of the other side and preceded and followed by a papilla. Spermathecae pear-shaped with short ducts; diverticula absent (?)..............*D. lumbricoides* Perrier 1872.

Synonymy of **Digaster** and **Perissogaster**

The genus *Digaster* Perrier 1872 is here extended to include the three trigastric species formerly placed in *Perissogaster* Fletcher 1887 *a*. Union of the two genera is necessitated, in the presence of close general similarity, by the discovery in the present investigation of intraspecific variation from two to three gizzards, in *D. perrieri* (p. 108). In this species the trigastric condition is not associated with abnormality in the distribution of other organs and the occurrence of it in two specimens of the small sample available suggests that it may be a common phenomenon in the species.

The following section deals with the morphology of *Digaster* s.lat. and serves also to indicate the basic similarity of *Digaster* s.strict. and *Perissogaster*.

Morphology of **Digaster** s.lat.

Both *Digaster* s.strict. and *Perissogaster* range in size from small worms less than 50 mm. long (*D. gayndahensis*, *D. minor* and *D.* (= *Perissogaster*) *nemoralis*) to large worms over 150 mm., i.e. 6 inches, long *D. brunneus*, *D. lamingtonensis*, *D. longmani*, *D.* (= *P.*) *excavata* and *D.* (=*P.*) *queenslandica*). *D. lamingtonensis* is known to reach a length of 273 mm., *D.* (=*P.*) *excavata* to reach 334 mm. with a width of 15 mm., a very large earthworm, and *D. longmani*, the type specimen of which was 520 mm. long, qualifies to be termed a giant earthworm, one living specimen from Kyogle in northern New South Wales (p. 102) measuring 5 feet 5 inches (1,625 mm.) with a width of 1 inch.

Secondary annulation of segments is common in the genus but reference to it is omitted from specific descriptions below because it appears to vary with the state of contraction on fixing.

Pigmentation is variable interspecifically and is sometimes, perhaps usually, absent. The setae are in eight rows but there are no setal distance ratios which are constant for the genus. Intraspecific variation in the ratios seems generally to be slight. In *D. longmani* the setae are so small relative to the bulk of the worm that they clearly do not function in locomotion. In *D. armifera* and *D. perrieri* the ventral setae of segment xviii are replaced by penial setae the presence and somewhat similar ornamentation of which tend to confirm that the two species, which have many points of close similarity, including the unique location of the gizzards in v and vi, are very closely related. The only other species with penial setae is *D.* (= *P.*) *nemoralis* which shows affinities with them in other respects (see below).

The clitellum usually embraces xiv to the anterior portion of xviii, but sometimes (*D. armifera, D. brunneus*) extends on to xii. The male pores are usually, therefore, immediately postclitellian but it is shown in the discussion of the status of *Didymogaster* below that the pores in *Digaster* are sometimes intraclitellian. The male genital field is associated with accessory genital markings on adjacent segments or intersegmental furrows in nine species of the genus, these markings being absent only from *D. longmani* and *D.* (= *P.*) *queenslandica.* The type-specimens of *D. queenslandica* were immature but a specimen examined by Michaelsen (1916) was clitellate and the absence of accessory genital markings in this suggests that they are normally lacking in this species. *D. longmani* conforms with other species of the genus in having glandular pads in some of the anterior segments (see Boardman, 1932). Genital markings possibly serve to secrete a mucous sheath around concopulants and, in some cases at least, to aid adhesion by acting as suckers. In the present revision of *D. armifera* and *D. lamingtonensis* it is shown that papillae associated with the male field can be invaginated to form sucker-like depressions.

The pre-setal location of the female pores in xiv is normal in the Megascolecidae but the diagonal orientation of the pores which is characteristic of *D. longmani* is unusual. Although spermathecal pores appear to lie in intersegmental furrows 7/8 and 8/9 and, in addition, in some specimens of *D. longmani* in 6/7, they probably always are situated on the extreme anterior border of the segment behind the furrow, i.e., the segment in which their spermathecae lie. All species of the genus excepting *D. lumbricoides* have been shown to possess spermathecal diverticula. The inadequate and contradictory nature of the type-description of the latter species suggests the possibility that they were overlooked.

The position of the first dorsal pore is believed to be important in determining relationships in the Oligochaeta. Gates' characteristically thorough examinations indicate that its position is constant intraspecifically; for instance, it was in 12/13 in 71 specimens of an Octochaetine species he examined (1961 p. 648). In the Lumbricidae, Muldal (1952) has shown that heterogeneity in location of the first dorsal pore is associated with significant genome differences and other morphological divergence. It is not unlikely that variation which exists in its location in *Digaster* is indicative of polyphyly. In *D. armifera* and *D. perrieri,* which resemble each other, and stand apart from the rest of the genus in several features, the first dorsal pore lies in 11/12. The location in *D.* (= *P.*) *nemoralis* is "after about segment x or xi" according to Fletcher (1888) and this species is morphologically very similar to the latter two species. It is the only other species of *Digaster* with penial setae. Re-examination of a paratype reveals that the latter resemble those of *D. perrieri* very closely. Furthermore it has tufted organs in iv, described by Fletcher as salivary glands, which appear in the re-examined type and paratype to be (enteronephric?)

nephridia. However, re-examination of the same paratype reveals a distinct dorsal pore in 10/11 and a possible rudiment in 9/10, though, owing to conspicuous secondary annulation and extreme indistinctness of setae, it is not possible to be certain of the location. Elsewhere in the genus the first dorsal pore lies in 11/12 only in *D. gayndahensis* which does not seem to be more closely related to these species than to other members of the genus, lacks penial setae and has the gizzards one segment behind those in *armifera* and *perrieri.*

" Duplication " of the gizzards was considered by Michaelsen and Stephenson to be derived from the monogastric condition of the " *Notiodrilus* ancestor " of the Megascolecidae. The author has elsewhere disputed the validity of the *Notiodrilus* theory and has presented evidence that a trigastric condition is perhaps primitive in the Megascolecidae (Jamieson, 1963).

A striking feature of *Digaster* is the tendency to complex folding of the internal walls of the oesophagus and to the development of segmental dilation of the lattre so that structures which are morphologically very similar to calciferous glands are found in some species. Paired pouches are present in x to xiii, and less developed in xiv to xvi, in *D. perrieri* (p. 108). Fletcher (1888) has described " calciferous glands " in *D.* (= *P.*) *nemoralis* in x to xiv where they are " not quite so completely pinched off " as in other genera and this is confirmed in the re-examination of the holotype and paratype. Also vascularized dilation and plication of the oesophagus have been described for *D. armifera* (p. 93), *D. brunneus* Spencer 1900, *D. lamingtonensis* (p. 99), *D. longmani* Boardman 1932, *D.* (= *P.*) *excavata* Fletcher 1887 *a* and *D.* (= *P.*) *queenslandica* Fletcher *ibid.* Folding and vascularization without dilation is described for *D. gayndahensis* (p. 97). The condition in *D. lumbricoides* is undescribed, and in *D. minor* Spencer 1900 denies the presence of vascular swellings and of calciferous glands. The omission of reference to calciferous glands in the Megascolecinae by Stephenson (1930) has been alluded to in the introduction above.

Prostates in *Digaster* are usually of the *Pheretima*-type. Sweet (1900) states that the prostates of *Perissogaster* (now *Digaster*) *excavata* are intermediate between tubular and " lobate " (*Pheretima*-type) prostates, the conspicuous central lumen having in some cases only seven or eight side branches (for the significance of this see Introduction, above). Michaelsen (1916, pp. 22-23) has pointed out that the prostates of *Perissogaster queenslandica,* said by Sweet *ibid.* to be tubular in one specimen, are intermediate between those of *excavata* and those of Megascolecinae with typical *Pheretima*-type prostates.

No taxonomic significance can be attached at present to the segment of origin of the intestine in *Digaster.* In one species it is said to commence in xvi, in two species in xvii and in four species in xviii.

The last hearts lie in xii in nine species. The location in xiii, in *D. perrieri* (re-examination) and *D.* (= *P.*) *nemoralis* (confirmation of Fletcher 1888 from re-examination of the holotype and paratype), is interesting in view of their close similarity in other respects. The work of Gates (e.g. 1961, p. 653) indicates that the position of hearts is constant within single genera and perhaps suggests that these two species should be placed in a separate genus from *Digaster.* However, this would ignore the apparent close affinity between *D. perrieri* and *D. armifera* which has last hearts in xii. The usefulness of the vascular system in classification is thus, in this respect, still in doubt.

Commissural vessels commence in vi in *D. brunneus, D. gayndahensis* and *D. lamingtonensis* but they commence in iv in *D. longmani.* The blood system is difficult to elucidate even in well-preserved material and it is possible that the commencement in iv in *longmani,* the great size of which facilitates investigation, is characteristic of the genus.

Holandry (testes and funnels in x and xi) is general in the genus but metandry (these organs in the posterior segment only) has been described for *D. brunneus* Spencer 1900 and *D. longmani* (p. 104). Such variation intragenerically is of common occurrence although it was once considered to merit generic separation (*Stuhlmannia* and *Eudriloides*, in the Eudrilidae, are still separated on this basis alone).

Meronephridia occur in all species, holonephridia being absent; pseudo-tufted nephridia formed by apposition of ducts of meronephridia occur in at least *D. armifera*, *D. perrieri*, *D.* (= *P.*) *excavata* (?), and (in both syntypes re-examined) in *D.* = *P.*) *nemoralis*. Some of these are known to be enteronephric in *D. armifera* and probably are in *D. nemoralis*. Micromeronephridia in anterior segments in *D. lamingtonensis* are probably enteronephric and in the grouping of their ducts show a condition which approaches the pseudo-tufted nephridia of other species. The occurrence of " meganephridia ", i.e. megameronephridia, in posterior segments is frequent in the Megascolecinae and they occur alongside micromeronephridia in *D. lamingtonensis* and *D. longmani*, which show close morphological affinities and are the only species of *Digaster* with the dorsal pores in 5/6, and in *D.* (= *P.*) *queenslandica*. They do not occur in *D. perrieri* and *D. armifera*. The ventral nephridia are said to be larger in *D.* (= *P.*) *nemoralis* by Fletcher (1888) but this is not confirmed from re-examination of the types where the apparent ventral enlargement is seen to be due to aggregation of micromeronephridia. The condition in other species is uncertainly known.

The Status of **Didymogaster**

Didymogaster, which contains the single species, *D. sylvaticus* Fletcher 1886 *a*, is the only remaining genus of the Megascolecinae with more than one oesophageal gizzard. Fletcher's definition of the genus (1886 p. 555):—

" Clitellum of about five segments from xiii or xiv to xviii; male pores on xviii; female pores on xiv; eight rows of setae; two gizzards "

was at the time of composition equally applicable to *Digaster* with the single exception, which is not now applicable, that the male pores were " intraclitellian " in the material referred to *Didymogaster* whereas in Perrier's account of the type-species, *Digaster lumbricoides*, they appeared to be " post-clitellian ". Such a distinction is of questionable significance. Furthermore, in *Digaster longmani* (p. 102) the clitellum extends on to the segment behind the male pores and in *D. brunneus* Spencer 1900 and *Perissogaster* (now *Digaster*) *queenslandica;* Michaelsen 1916 reaches furrow 19/20. The three species thus show the intraclitellian condition.

Beddard (1895) argued for union of *Didymogaster* with *Digaster* but was not followed by Michaelsen (1900) or by Stephenson (1930). The author's reasons for supporting retention of *Didymogaster* as a separate genus, although Fletcher's definition no longer merits this, are outlined below.

The possession by *Didymogaster sylvaticus* of three pairs of spermathecae hitherto might have been used to distinguish *Didymogaster* from *Digaster* but variation from two to three pairs of spermathecae as a normal intraspecific character of *D. longmani* has been demonstrated in the present work and is known to occur intraspecifically in other Megascolecidae. Nevertheless, in *Didymogaster sylvaticus* the spermathecae open in ix, x and xi, two segments behind their ampullae, in a segmental position, and not as in *Digaster*, at the anterior border of the same segment, i.e. in furrows 7/8, 8/9 and sometimes also 6/7.

The dorsal blood vessel of *D. sylvaticus* is described by Stephenson (1932) as single, as in *Digaster*. Fletcher (1886) described a double " supra-intestinal trunk " from which the hearts arose (clearly the dorsal vessel). The two constituent parts,

he stated, were confluent at and for a short distance on either side of each septum. The author has observed bifurcation of the dorsal vessel in this way in a specimen of *D. sylvaticus* from Commodore Heights, Pittwater, New South Wales, used for karyotypic studies. This bifurcation, in conjunction with the presence of hearts in xiii, militates against union of *Didymogaster* and *Digaster*.

Stephenson (1932) noted testis-sacs in this species. These are unknown in *Digaster*.

The location of the first dorsal pore in 4/5 noted by Stephenson (1932) and confirmed by the author in the above-mentioned specimen, distinguishes *D. sylvaticus* from all species of *Digaster* except *D. lumbricoides*, the description of which is manifestly unreliable.

Didymogaster thus differs conspicuously from *Digaster* in features of the spermathecal, vascular and male genital systems which taken together appear to constitute sufficient grounds for continued separation of the two genera.

Digaster armifera Fletcher 1886

Figs. 1-2

Digaster armifera Fletcher 1886, *Proc. linn. Soc. N.S.W.*, (2) i, pt. III, 947-951, Pl. 13, figs. 1-3.

Digaster armifera; Beddard 1895, Monograph, 486.

Digaster armifera; Michaelsen 1900, Tierreich, Lief. 10, 197.

Type-locality: The neighbourhood of Sydney, N.S.W., i.e. at Marrickville (3 under a stone, April [1886?]; 1 under a stone at the same spot, July, 1886) and at Auburn, near Parramatta (6 under logs and bark, August and September, 1886).

Material examined: (All except the last two lots were presented to the Australian Museum by J. J. Fletcher, November, 1924).

1. Australian Museum Reg. No. W. 1380; many specimens labelled " *D. armifera* ", from Homebush, May 24, 1888; Ryde, June 4, 1887 and Oatley, October 30, 1886, March 3, 1887 and also an " original specimen " from Old Newington, June 25, 1887 (all near Sydney). These are not type-localities and the specimens, although labelled as types, cannot be regarded as such.

2. Australian Museum Reg. No. W. 1406; 11 specimens, labelled " *D. armifera* ", from Penshurst (near Sydney), August 2, September 30, 1890.

3. Australian Museum Reg. No. W. 1501; 3 specimens, labelled " *Digaster* ", from Oatley, October 19, 1889, and Sutherland, April 19, 1890 (both localities near Sydney).

4 and 5. Australian Museum Reg. No. W. 1527 amd 1528; two specimens labelled " *D. armifera* ", from Turramurra to Thornleigh, October, 1892, and from Carlingford, July 8, 1893 (both localities near Sydney).

6. National Museum Melbourne, Reg. No. G.98; several surface-hardened specimens, labelled " *Digaster armifera* ", Baldwin Spencer Collection. No locality given.

7. Australian Museum Reg. No. W. 3764; 3 clitellate and 5 aclitellate specimens from Galston Gorge (near Sydney); in rich black sandy soil amongst rocks in *Eucalyptus-Casuarina* woodland, May, 1962, collected by B. G. M. Jamieson.

Morphological Data

These data are derived mainly from the specimens from Galston Gorge. Of these, the clitellate specimens are referred to as W. 3764 a-c. A qualitative external examination of the five aclitellate specimens from this locality, which range from 54 to 95 mm. in length, revealed no differences, other than those pertaining to the reproductive condition, from the clitellate specimens. Significant variation and some other information from specimens from other localities is also included.

Dimensions: Length 72 to 137 mm., with the mode at 100 mm. (11 specimens, W.1380, W.1406, W.1501, W.3764). Maximum width between 3 and 4 mm.—*Number of segments:* 105 to 241 (4 specimens, W.1380, W.1501, W.3764).—*Colour:* In life the specimens from Galston Gorge were pigmentless grey with the clitellum and forebody suffused with pink.—*Prostomium:* Epilobous ca. 1/3 (7 specimens, W.1380, W.1406, W.1501, W.3764) with the dorsal tongue broad and blunt, or acute.—*Setae:* Apparently uniform. The following data are from specimens W.3764, a-c and W.1501, a. In segment ix *cd: ab* = 1·2-1·6 (mean = 1·4); *bc: aa* = 0·6-0·8 (mean = 0·7); *dd: u* = 0·5 (four specimens); in segment xxv *cd: ab* = 1·4-1·8 (mean = 1·7); *bc: aa* = 0·8-0·9 (mean = 0·8); *dd: u* = 0·6 (four specimens).

Clitellum: Annular but often indistinct ventrally, 1/3 xiii, 1/2 xiii to xvii, 1/n xvii, 1/3 xviii, 1/2 xviii (10 specimens, W.1380, W.1406, W.1501, W.3764).—*Male genital field:* This was examined in specimens from all localities and sources listed. Its considerable variability between specimens from different localities was found to be no greater than that within samples from a single locality. Where conspicuous variation occurred it seemed referable to the degree of maturity of the male field. The greatest development of the field was seen in a specimen from Penshurst, Australian Museum Reg. No. W.1406, a, (see fig. 1a) where it has the following characteristics:—

Segment xviii is filled longitudinally by a whitish tuberculum the rounded lateral extremities of which reach to mid *bc* on the right and on the left include seta *c*. The central region of the tuberculum is slightly constricted. The male pores are a pair of short transverse slits at the sites of the absent setae *ab* (the latter are replaced by penial setae). In mid *bc* on each side the tuberculum bears two elliptical sucker-like depressions, one in front of and the other behind the setal zone.

A smaller but similar tuberculum is present on each of segments xvii and xix, the anterior extending laterally to mid *ab*, the posterior including setae *a* and *b*. Each tuberculum has a pair of suckers which lie just median to seta *a*. A suggestion of a median unpaired sucker was observed on that of xix.

All the other Penshurst specimens showed the paired suckers laterad of the male pores and on segment xix, but only one of these possessed them (a pair) on the tuberculum of xvii.

Ten specimens, from all the other localities, have fields very similar to that of the specimen described above. The absence, from some, of the suckers, of the tubercula of xvii and (or) xix, and the presence in a few of two discrete papillae in place of a single tuberculum are probably due to lesser maturity of the fields.

One of the preserved specimens and a further living specimen, both from Galston Gorge, have elliptical elevations in place of suckers. It seems probably, therefore, that muscular depression of these elevations produces the suckers and that the latter aid in adhesion of concopulants.

Accessory genital markings: A midventral squarish glandular pad is present in each of segments xi and xii (fig. 1a) in all mature specimens. These pads reach to mid *ab* and in all but two of the eleven specimens examined they fill the segments

longitudinally. In the figured specimen (W.1406, fig. 1a) the posterior pad did not extend behind the setal annulus of xii. The centre of each pad usually has a sucker-like depression of irregular outline.

Female pores: minute, a pair anteromedially from setae *a* of xiv. (Specimen W.3764, a-c; W.1501, b; not seen in others.)

Spermathecal pores (fig. 1a): Visible as paired crescentic protrusions of viii and ix into intersegmental furrows 7/8 and 8/9 in line with or slightly laterad of setal lines *a* (Specimens W.3764 a-c; W.1380, a, b; W.1406, a; W.1501, a, b).

Dorsal pores: First dorsal pore in 11/12 (W.3764, a-c; W.1501, a).

Internal characteristics:—

Septa: In sections of W.1380, a, 6/7 to 12/13 are thickened, 7/8 to 11/12 very thick, 6/7 and 12/13 about half as thick though still fairly strong, the remainder thin; septum 3/4 is the most anterior septum recognizable.—*Alimentary canal:* A strong-walled spherical gizzard lies in each of v and vi. In segments vii to xiv the oesophagus is highly vascularized and pouch-like on each side. Transection reveals that, although the walls of the oesophagus are complexly folded, it has no diverticula. The intestine

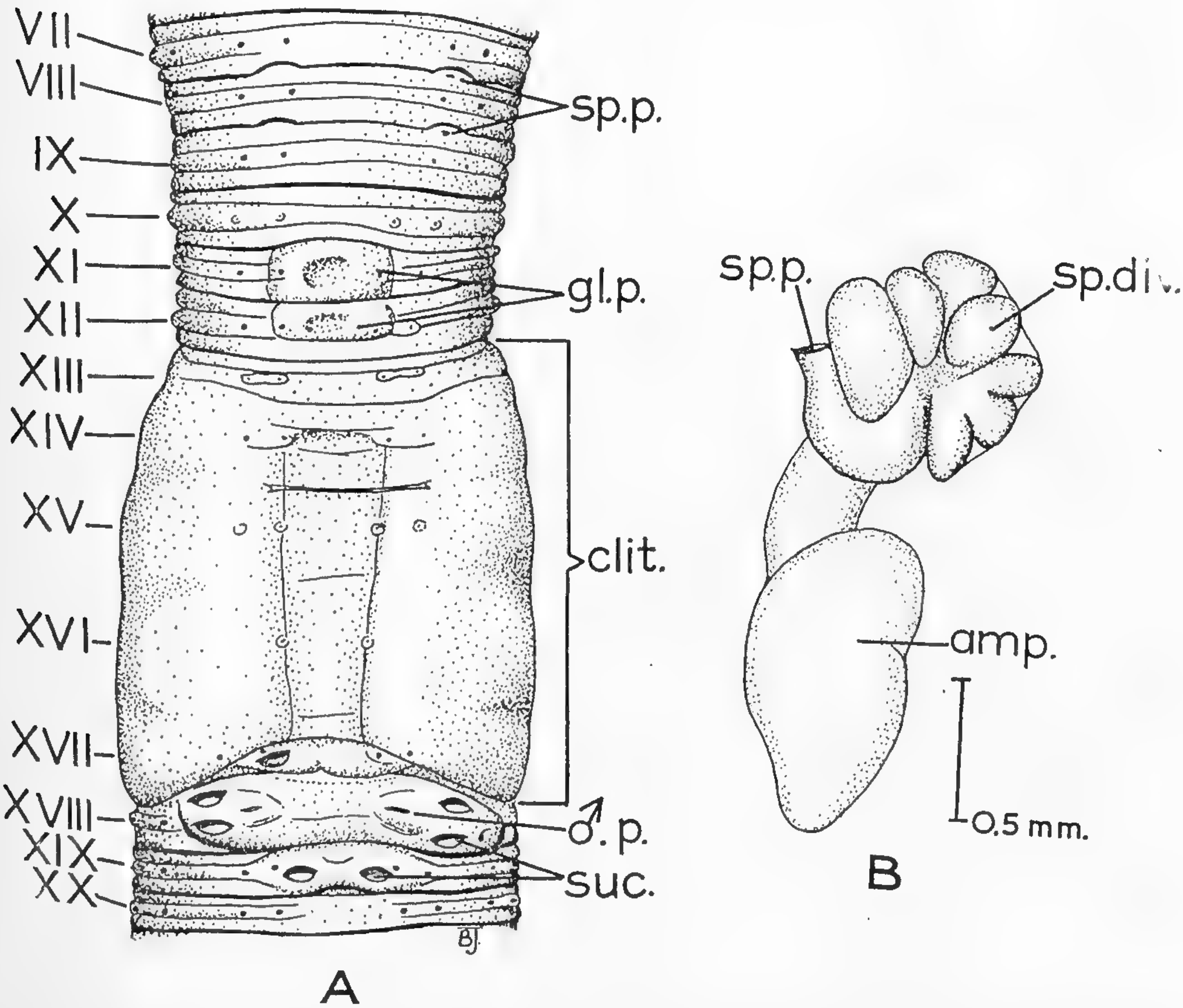

Fig. 1: A, *Digaster armifera* ventral surface in the region of the genital pores (specimen W.1406 a, from Penshurst). B, ventral view of right posterior spermatheca of same specimen. amp., spermathecal ampulla; clit., clitellum; gl.p., glandular pads; ♂p. male pore; sp.div., spermathecal diverticulum; sp.p., spermathecal pore: suc., suckers.

commences in xvii (W.3764, a: W.1406, a). Transection in xviii reveals no typhlosole. In longitudinal sections (W.1380, a) it can be seen that each plication of the oesophageal wall consists of a single layer of cubical epithelium overlying a very large blood sinus.

Blood vascular system: The dorsal vessel is single and is greatly enlarged on the intestine. In xi to xii it gives off a pair of commissural vessels in each segment. Those in xi are very slender; the remainder are large. In xv and posterior segments the dorsal vessel gives off a vessel on each side to the laterodorsal wall of the alimentary canal. In xiii and xiv the wall is vertically striated by blood vessels but the paired vessels are not detectable (W.3764, a).

Nephridia: A pair of tufted enteronephric nephridia formed by apposition of the ducts of meronephridia is present in each of segments v and vi, their ducts passing forward to enter the alimentary canal in the region of the junction of pharynx and buccal cavity. Tufted nephridia in vii, and micromeronephridia in more posterior segments, are confined to the segment of origin and probably discharge through the parietes. (W.3764, a, and sections of W.1380, a.)

Anterior male organs: Shining sperm funnels and free sperm masses lie in x and xi. Large racemose seminal vesicles project into ix and xii from the posterior and anterior septum respectively; the posterior are the larger (W.3764, a). In the sections (W.1380) well-developed testes and funnels are present in x and xi and large racemose seminal vesicles in xii only.

Posterior male organs: Broad racemose prostate glands discharge in xviii and pass posteriorly through three segments (W.3764, a). The vas deferens of each side runs back to join the prostate duct at the ental end of the latter (W.1406, a; W.1380, b). It then runs with the prostate duct in a common muscular sheath and is distinguishable by its anterior position and its ciliation. The lumina of the two ducts unite only ectally near their common pore through which the penial setae project. Branching of the prostate duct within the gland is visible (W.1380, a, sections).

Penial setae (fig. 2): Removal of the right penial setal follicle of two specimens (W.1406, a, and W.3764, a) revealed three penial setae in each follicle. Each curves gradually from near the base so that the ectal end subtends a right angle or less with the basal portion. The ectal end is slightly thickened and bears somewhat irregular circlets of minute spines. The extreme tip is free of spines and forms a web (fig. 2, c). The lengths of the three penial setae of the right follicle of specimen W.1406, a, are 1·1, 1·5 (fig. 2, c) and 1·9 mm., with a width ental to the ornamented part of 20μ. The two setae mounted from the right follicle of W.3764, a (fig. 2, a and b) are respectively 1·3 and 1·7 mm. long and of the same width as in the other specimen.

Female organs: A pair of ovaries in xiii (W.3764, a; W.1380 sections).—*Spermathecae* (fig. 1b): Paired in viii and ix. The spermatheca figured is from specimen W.1406, a, the male field of which is shown in fig. 1a. Each spermatheca is about 2 mm. long, has an ovoid ampulla and a wide duct into which a many chambered diverticulum opens ectally (W.1406, a; W.1501, a; W.3764, a). In sections (W.1380) the duct appears to contain a spermatophore.

Remarks

The above account extends and largely confirms the type-description of Fletcher (1886). The re-examination necessitates, however, considerable emendment of the description of the male genital field and of the penial setae, both characters of great taxonomic value. Fletcher described the two pairs of the sucker-like organs, here described (fig. 1a), as pores, either of accessory glands or for the protrusion of penial setae. He considered similar structures on xix to be, possibly, pores. The male genital field is illustrated for the first time in the present account.

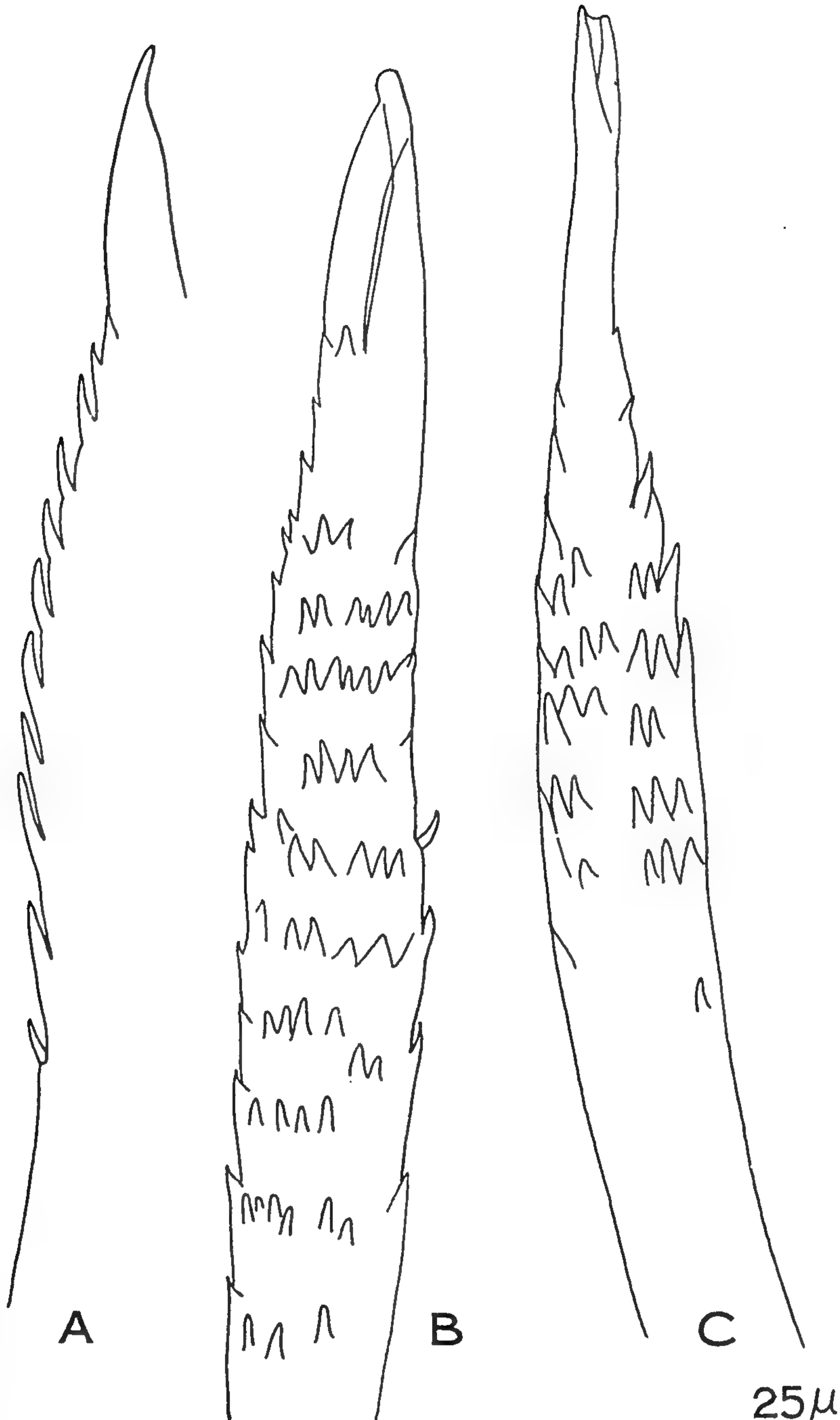

Fig. 2: *Digaster armifera*, A and B, ectal ends of two penial setae from the right follicle of specimen W.3764 a, from Galston Gorge. C, intermediate of three penial setae from the right follicle of specimen W.1406 a, from Penshurst.

Fletcher (*ibid.*) described the penial setae as chelate. Reference to his illustration of a penial seta and examination of penial setae of new material and material which was in Fletcher's possession indicates, however, that he mistook a web-like expansion of the apex of the seta, with thickened edges, for bifurcation (see fig. 2c, above).

This species, recorded from numerous localities in the vicinity of Sydney, was clearly one of the commoner species of the Sydney region. Most of the localities where it was found by Fletcher have now been built over and it will be interesting to investigate whether the populations sampled have survived human settlement, cultivation, and the inevitable introduction of lumbricids. The species is still common in the relatively undisturbed *Casuarina-Eucalyptus* woodland of the Galston Gorge reserve.

In having the gizzards in v and vi *D. armifera*, with *D. perrieri*, differs from all other species of *Digaster* s. strict., in which the gizzards are in vi and vii. In trigastric specimens of *D. perrieri* each of segments v to vii contains a gizzard, as in the former genus *Perissogaster*, and the condition in *D.* armifera need not, therefore, be considered to indicate polyphyly in *Digaster* s. lat.

Digaster gayndahensis Spencer 1900

Digaster gayndahensis Spencer 1900, *Proc. roy. Soc. Victoria*, *13*, (new series), *13*, pt. 1, p. 67, fig. 106, 107, 108.

Type-locality: Gayndah, Queensland (see Material Examined, below).

Material Examined: 2 clitellate specimens, one of which had previously been dissected and had had the male genital field excised, from " scrub behind Gayndah, Oct. '91 ". National Museum, Melbourne, registration, *Digaster gayndahensis*, No. G.99.

There is no reason to doubt that this is type-material, that the dissected specimen is the holotype and the undissected specimen a paratype.

Morphological Data

Unless otherwise indicated, these data are from the paratype.

Dimensions: Length 44 mm.; maximum width (forebody) 4 mm.—Number of segments: 95.—*Colour:* Pigmentless buff in alcohol with the clitellum darker in the holotype.—*Prostomium:* Epilobous, $\frac{1}{2}$, with narrow, open, dorsal tongue.—*Setae:* Small, uniform, difficult to discern on the clitellum; in segment ix $cd : ab = 1{\cdot}3$; $bc : aa = 0{\cdot}8$; $dd : u = 0{\cdot}6$; in segment xxv $cd : ab = 2{\cdot}2$; $bc : aa = 1{\cdot}1$; $dd : u = 0{\cdot}7$ (paratype).

Clitellum: Ring-shaped and thick; embracing xiv to xviii and possibly part of xiii.

Male genital field (fig. 3a): The male pores are situated equatorially and in setal lines *ab* in xviii, each being visible as a transverse slit in a minute papilla. The two papillae lie within a single lip-like ridge which reaches a little laterad of setal lines *b*. Medially the anterior and posterior lips so formed almost meet. Accessory genital markings are present in intersegmental furrows 19/20, 20/21 and 21/22. Each consists of an oval pad with the long axis transverse to the long axis of the body. The boundary of each pad is raised into a lip so that the pad has a sucker-like appearance. Each pad extends antero-posteriorly between the setal zones of the adjacent segments and laterally to midway between setal lines *a* and *b*.

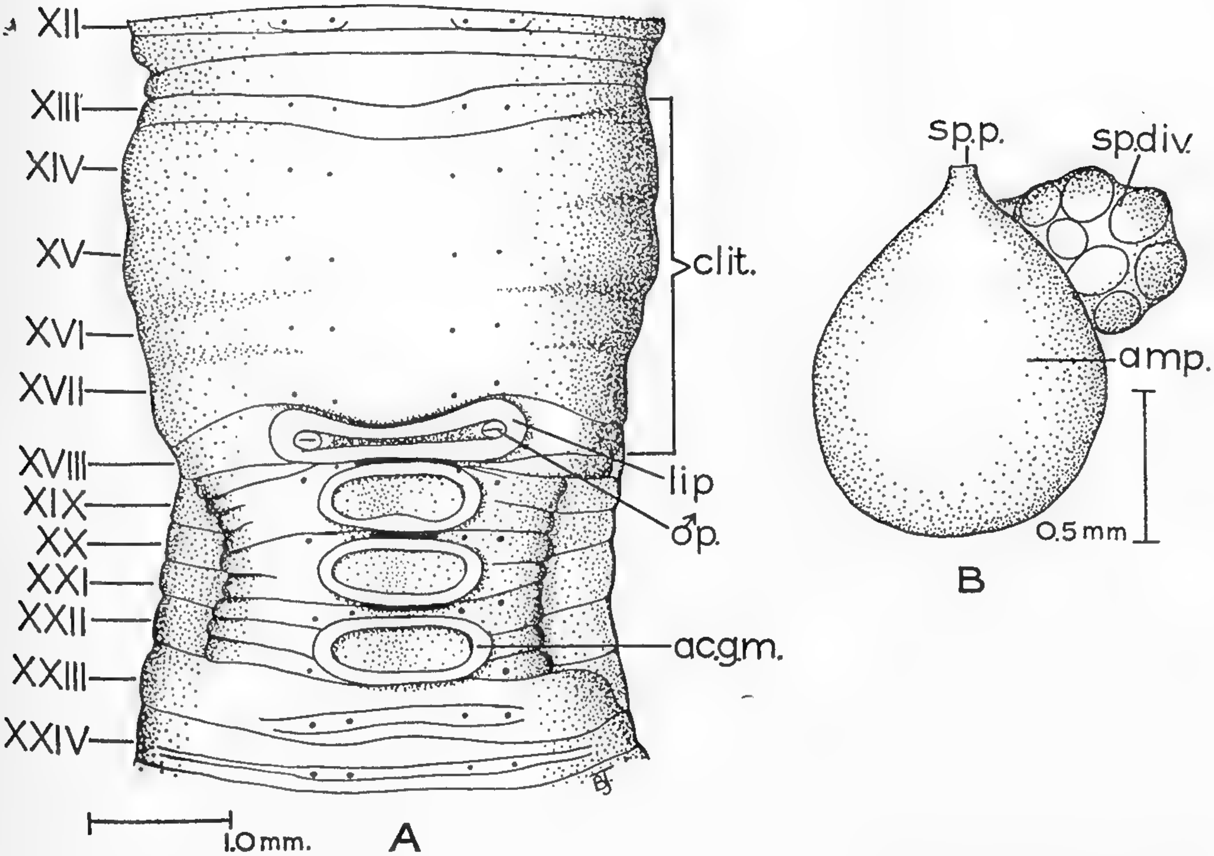

Fig. 3: *Digaster gayndahensis*, A, male genital field of paratype; B, dorsal view of right spermatheca of holotype. a.c.g.m., accessory genital marking; clit., clitellum; lip, lip surrounding male pores; ♂p., male pore.

Female pores: Not visible.

Spermathecal pores: Paired in intersegmental furrows 7/8 and 8/9, which they cause to protude forwards in their immediate vicinity.

Dorsal pores: The first visible were in 11/12.

Internal characteristics:—

Septa: Septa 3/4 to 8/9 very delicate; 9/10 thin; 10/11 to 13/14 moderately thickened and somewhat funnel-shaped, 14/15 thin; the rest delicate.

Alimentary canal: The pharynx and associated glandular tissue is situated in front of septum 3/4. A large, strong-walled, approximately spherical gizzard lies in each of vi and vii, a fairly long region of thin-walled oesophagus intervening between the two. In ix and x the oesophagus has a deep dorsal fold which is perhaps not normally present. Transection of the oesophagus in ix and xiv reveals folding of the walls as in other *Digasters.* The intestine begins in xviii but does not immediately reach its full width.

Blood vascular system: The dorsal vessel was traced anterior of the gizzard in vi. Paired commissural vessels were observed running ventrally from the dorsal vessel in vi to xii only. In x to xii these were large and heart-like.

Nephridia: From the segment containing the brain (iii?) posteriorly micro-meronephridia are fairly common. They appear to be attached to the integument and not to the septa, but contraction of the specimen and the necessity to maintain it as intact as possible rendered examination difficult. No enteronephric nephridia were seen.

Anterior male organs: Thick, convoluted bodies on the anterior faces of septa 10/11 and 11/12 are probably sperm funnels. Sperm funnels were seen in these positions in the holotype on re-examination. Seminal vesicles were seen on the posterior faces of these septa in both specimens.

Posterior male organs: A racemose, ovoid prostate gland with several closely applied lobes opens to the exterior by a very short duct on each side in xviii. Vasa deferentia were not seen.

Penial setae: Absent.

Spermathecae (fig. 3b): In the holotype there is a pair of spermathecae in each of segments viii and ix. Each spermatheca has a spherical ampulla, approximately 1 mm. wide, which is almost sessile on the body wall. An ovoid diverticulum, 0·4 mm. wide, opens into the ectal region of the ampulla. The diverticulum lies lateral to the ampulla and is partly hidden by the latter *in situ;* it appears to contain several sperm chambers.

The left anterior spermatheca has a diverticulum on each side. The spermathecal ampullae of the paratype fragmented very readily and released large numbers of what appeared to be nematodes. Description of them is therefore excluded from this account because of the possibility that they are abnormally developed.

Remarks

The above description of the two remaining syntypes of *D. gayndahensis* greatly extends and partly emends the brief type-description of Spencer (1900). Points of divergence of the present account are: the first dorsal pore is shown to lie in intersegmental furrow 11/12, not 37/38, thus conforming with *D. armifera;* the gizzards are shown to lie in vi and vii, not vii and viii, and the intestine appears to commence in xviii, not in xvii; paired commissural vessels are described in vi to xii, being large and heart-like in x and xii, whereas Spencer noted hearts in ix to xiii.

Digaster lamingtonensis Michaelsen 1916

Fig. 4

Digaster lamingtonensis Michaelsen 1916. Kungl. Svenska Vetenskapakad. Handlingar, 52, no. 13, pp. 20-22, taf. 1, fig. 1, 2.

Type locality: South Queensland, Glen Lamington (November, 1911. 1 specimen).

Material examined: 13 aclitellate specimens in alcohol, of which two have distinguishable genital apertures, from Nordlington Farm, Tyalgum Creek, Tweed River, Queensland, presented by E. M. Embury, September 16, 1938. Australian Museum Registration No. W.3425.

Morphological Data

Only the two specimens which show male orifices are described below. For each character the two specimens are dealt with in the same order. Where no distinction is made the character is the same for the two specimens.

Dimensions: Length 265 mm., 273 mm.; maximum width (in the forebody) 5·5 mm., 7 mm.

Number of segments: 306, 295.

Colour: Pale straw colour in alcoholic preservation.

Prostomium: Tanylobous but giving an illusion of an epilobous condition because the peristomium is unusually short antero-posteriorly.

Setae: Lumbricine, all very small, fairly closely paired. In segment ix $cd: ab = 1{\cdot}3\text{-}1{\cdot}5$; $bc: aa = 0{\cdot}8\text{-}1{\cdot}2$; $dd: u = 0{\cdot}6\text{-}0{\cdot}7$; in segment xxv $cd: ab = 1{\cdot}6\text{-}1{\cdot}7$; $bc: aa = 0{\cdot}7\text{-}0{\cdot}8$; $dd: u = 0{\cdot}6\text{-}0{\cdot}7$ (two specimens).

Clitellum: Not present.

Male genital field (fig. 4a): The male pores are two equatorial transverse slits in xviii, at the sites of the absent ventral setae, and are slightly less in extent than a ventral setal couple. In the first specimen each pore is situated on a small dome-shaped papilla and the two papillae lie in a glandular area which includes two sucker-like depressions in intersegmental furrow 17/18 and a similar, unpaired depression in 18/19 on the left side (see discussion). The median limit of each sucker is approximately in the same longitudinal line as the male porophore of its side and laterally each extends to midway between setal lines *b* and *c*. The other specimen shows only slight glandular modification of the epidermis around the male pores in xviii. It is improbable that it is in the breeding condition.

Female pores: Visible only in the second specimen as a pair of minute pores 0·17 mm. apart (i.e., less than the width of a setal couple) and situated in a circumsegmental furrow in front of the setal zone of xiv.

Spermathecal pores: A pair in each of viii and ix very near the anterior border in or very slightly lateral to setal lines *a*. Each pore visible as a crescentic area the convexity of which pushes the anterior intersegmental furrow slightly forward.

Dorsal pores: Clearly visible; the first in intersegmental furrow 5/6 (specimen 2; this region damaged in the other).

Internal characteristics:—

The following data derive solely from dissection of specimen a. Septa: 5/6 thin; 6/7 moderately thickened; 7/8 and especially 8/9 to 12/13 thick and funnel-shaped; 13/14 to 17/18 successively thinner and transverse, 17/18 being flimsy. Behind this the septa are thin.

Alimentary canal: The pharynx and tendinous glandular material adherent to it extend back to septum 5/6. A large, strong-walled gizzard in the form of a truncated cone with the narrow end posterior lies in each of segments vi and vii. The oesophagus is slender in viii and ix. In x to xvii it is wider and a reticulum of what appear to be blood sinuses is visible on its surface. The gut expands abruptly as the intestine in xviii.

Blood vascular system: The single, median, anteriorly narrowing dorsal vessel was traced forward as far as the cerebral ganglia. It gives off a commissural vessel on each side in each of segments vi to vii. In viii and posteriorly the commissural vessels were shown to connect with the ventral blood vessel; demonstration of the connection in the more anterior segments was not achieved. Only in ix to xii do the commissural vessels attain the thickness of the dorsal vessel. In vi to viii a vessel which is smaller than the commissural vessel runs from the wall of the gut and joins the latter vessel ventrally, but whether the lumina become confluent was indeterminable. A dorsal (paired?) vessel runs antero-posteriorly along, and imbedded in, the dorsal surface of the gut in ix to xii. It appeared possible that this vessel is not continuous through the septa. It gives off a vessel on each side which passes downwards around the oesophagus and is barely discernible from the numerous lacunae of the oesophageal sinus. These perioesophageal intramural

vessels are equatorial in x to xii but are anterior in ix. In xii a connection between the upper extremity of the right commissural vessel and the dorsal intramural vessel was demonstrated. In xiii, where there are no commissurals, a pair of dorsal intramural vessels originates from the anterior wall of the segment (from the commissural vessels of xii) and the two vessels diverge backwards and equatorially pass ventrally around the gut as intramural vessels. In xiv and the succeeding segments there are no dorsal intramural vessels and the pair of equatorial intramural perioesophageal vessels in each segment connects by free roots to the ventral face of the main dorsal vessel. The mottling of the wall of the gut in xiii to xvii becomes lesss obvious and is not visible on the intestine.

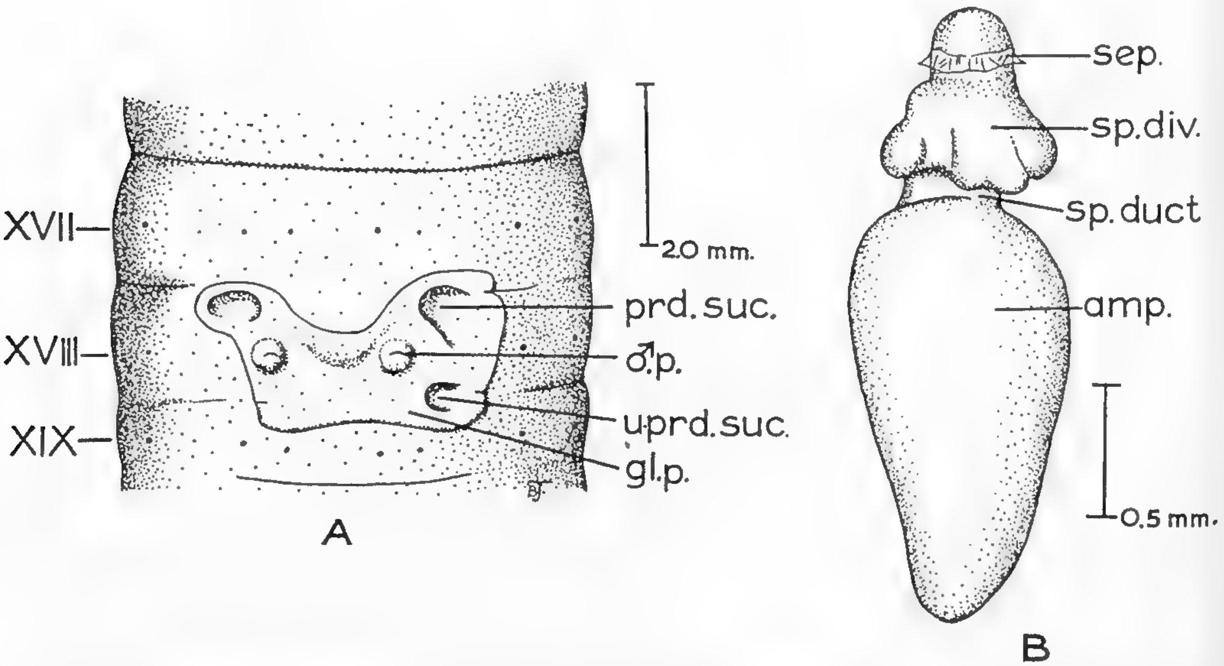

Fig. 4: *Digaster lamingtonensis*, A, male genital field of specimen W.3425 a. gl.p., glandular pad; u-prd.suc., impaired sucker; ♂p., male pore; prd.suc., paired sucker. B, dorsal veiw of right spermatheca of the same. amp., spermathecal ampulla; sep., septum; sp div., spermathecal diverticulum; sp.duct, spermathecal duct.

Nephridia: Micro-meronephridia are densely grouped in iii (i.e. the segment containing the cerebral ganglia and the anterior part of the subpharyngeal ganglion) to v. At least the ventral nephridia of the anterior segment have very long ducts which run in parallel rows anteriorly and medianwards to the region of the buccal cavity in this segment. It is probable that these nephridia are enteronephric. Behind v the nephridia are sparse and approximately equatorial and appear to be closed integumentary micro-meronephridia. In the hindbody, however, the median-most nephridium on each side is large and constitutes a mega-meronephridium, but again no funnel is detectable.

Anterior male organs: Holandric. A pair of sperm funnels was seen on the posterior wall of each of x and xi. A compact lobulated seminal vesicle lies on each side in ix and xii, flattened against the posterior and anterior septum respectively.

Posterior male organs: The pair of prostate glands opens to the exterior in xviii. The glandular part of each is compact, flattened and racemose with several major lobes. The duct is short and stout. The very thin, apparently single, vas deferens on each side runs to the ental end of each prostate duct where it becomes hidden by the base of the glandular part.

Penial setae: Absent.

Female organs: A pair of well-developed ovaries projects from septum 12/13 into xiii. Oviducts were not seen.

Spermathecae (fig. 4b): Paired in viii and ix. The right posterior spermatheca is 2·4 mm. long and has an ovoid, ectally tapering ampulla 0·93 mm. wide and a fairly stout duct which entally attains its maximum diameter of 0·38 mm. and is about half as long as the ampulla. Approximately the ectal third of the duct appears to be anterior to the septum which bounds its segment anteriorly. From the duct immediately behind the septum arises a large, dorsal, indistinctly lobed diverticulum which hides most of the duct. The other spermathecae are similar.

Remarks

The above account is based on hitherto undescribed material of *D. lamingtonensis* from the Tweed River. The description of the male genital field accords closely with that of Michaelsen (1916) for the single type-specimen which was also from South Queensland. The similarity extends even to the asymmetrical development of a single puberty marking, on the left side, behind the male pores. Michaelsen described the puberty markings as lying posteriorly in xvii and xviii, however, whereas in a mature specimen of the new material they are sucker-like depressions, in 17/18 and 18/19. It seems likely that in this species, as in *D. armifera*, the "suckers" are formed by muscular depression of papillae and that they aid in cohesion of concopulants.

Points of difference of the two accounts are generally minor. The oviducts opened by a single midventral pore in the holotype but discharged by two separate very closely paired pores in a Tweed River specimen. In both they are anterior in xiv. The setal distance ratios are not in accordance. Bifurcation of the prostate glands into two distinct lobes is shown not to be a constant feature of the species.

Digaster longmani Boardman 1932

Fig. 5

Digaster longmani Boardman 1932. *Mem. Queensland Mus.*, 10, pt. 2, pp. 125-127, fig. 1.

Type-locality: Tambourine Mountain, South Queensland (holotype and four fragments, including a head end, Queensland Museum, Reg. No. G.684). Not seen.

Material examined:—

1. Australian Museum Reg. No. W.3643. Five badly softened fragmenting specimens, the largest 4 feet 11 inches in alcohol, bull-dozed from soil in Kyogle State Forest, northern New South Wales, September, 1956, donated by Axel Poignant.

2. Australian Museum Reg. No. W.3644. One fine clitellate specimen, 4 feet 1 inch long, of which the male field had been destroyed by a ventral incision. From Kyogle State Forest, collected in early 1950's by W. T. Jones.

3. Australian Museum Reg. No. W.3669. 11 clitellate and 17 aclitellate specimens (complete); 8 clitellate and 4 aclitellate specimens (lacking the tail end). From a spur above Oaky Creek, Richmond Range State Forest, May 20, 1957; bull-dozed from red soil, Kyogle, and from the Toonumbar State Forest, spur above Iron Pot Creek, Kyogle, collector E. Pope (see Abs. Proc. Linn. Soc. N.S.W. 82, pt. 3, no. 385, May, 1957, p. 368 and August, 1957, p. 370, where Miss Pope gives ecological and other notes on these specimens).

Observations on what were perhaps specimens of *D. longmani* are given by Fleay (1956) in " Talking of Animals ", Jacaranda Press, Brisbane, pp. 6-7.

Morphological Data

These data are derived from the specimens collected by Miss Pope which bear the Australian Museum Registration Number W.3669.

Dimensions (Table 1): Length 860 to 1,025 mm. (2 feet 10 inches to 3 feet 5 inches) but a length of 1,625 mm. (5 feet 5 inches) has been recorded by Miss Pope (*in litt.*) in a live specimen suspended by the tail.

Table 1

Specimen	Length (mm.)	Greatest width (mm.)	Number of segments
W.3669, a	860	25	309
b	925	25	357
c	1,025	25	282
d	1,025	25	378
e	937	25	334
f	1,025	25	382

Number of segments (Table 1): 282 to 382.

Secondary annulation: Variable and probably dependent on the degree of contraction on fixation.

Colour: Darkish buff with the clitellum brownish black.

Prostomium: Broad and zygolobous (5 specimens) with sometimes a faint transverse furrow making it prolobous (specimen 3).

Setae: Minute relative to the size of the worm and presumably functionless.

In segment ix *cd: ab* = 1·3-1·8 (mean of six = 1·6); *bc: aa* = 0·4-0·5 (mean of six = 0·4); *dd: u* = 0·6-0·8 (mean of six = 0·7); in segment xxv *cd: ab* = 1·3-1·7 (mean of five = 1·5); *bc: aa* = 0·4-0·8 (mean of five = 0·6); *dd: u* = 0·7-0·8 (mean of five = 0·7).

In the tail region the ratio *bc: aa* increases though it does not reach unity.

Clitellum: Poorly developed and recognizable only by its brownish black colour and swelling round the dorsal pores, which are perhaps occluded in this region; embracing half or less of xiii to half or less of xix (specimens a-d, f). It is ring-shaped but is paler ventrally in xiv. In one specimen (e) it shows no ventral pigmentation, embraces xiv to ½xix, and is perhaps saddle-shaped.

Male genital field: The male pores are equatorial (specimens a, b, e, f) or sometimes (specimens c, d) just presetal on segment xviii in setal lines *a* (specimen b) or *b* (specimen d) or between these (specimens a, c, e, f). Usually each pore lies on a low mound of which only the median border is clearly defined. Clitellar pigmentation is lacking between these papillae and the existence of a male field is indicated by slight backward dislocation of furrow 18/19 between the ventral setal lines.

Female pores: A pair of female pores lies about half way between the setal zone of xiv and the anterior border of this segment. In four specimens (a-d) the right pore lies well anterior to the left, in one (f) the pores are obscured in a median pit, and in another specimen (e) they seem to be in the same transverse line.

Spermathecal pores: Two specimens (a, d) have three pairs of pores, in intersegmental furrows 6/7, 7/8 and 8/9, while the other four specimens have two pairs of pores, in furrows 7/8 and 8/9. The pores in all lie in setal lines *a*.

Dorsal pores: The first dorsal pore lies in intersegmental furrow 5/6 in five specimens. In a single specimen (e) the first detectable pore was in 6/7.

Internal characteristics (the following data are derived from specimen W.3669, a):—

Septa: The first visible, 4/5, is poorly developed and is fused to the pharynx. 5/6 and 12/13 are strong, 6/7 to 11/12 are very thick and the succeeding septa are thin. The septa back to 17/18 are funnel-shaped and the remainder transverse. Successive thickened septa are united by tendons.

Alimentary canal: The large ovoid pharynx ends against septum 4/5, with which it is fused, and sends numerous muscle bands and tendons to septum 5/6. In v the gut is thin-walled and pouch-like. A large strong-walled gizzard in the form of a truncated cone with the narrow end posterior lies in each of segments vi and vii. The anterior base of the cone is thin-walled. Only a very small length of oesophagus intervenes between the two gizzards and it is hidden in septum 6/7. The oesophagus is slender in segments viii to xii and bears no oesophageal diverticula. In xiii it is swollen and vascularized and transection in this segment shows that its wall is thin but is thrown internally into numerous discontinuous folds which, especially ventrally, appear to contain blood sinuses. The oesophagus in xiv is also internally ridged but is less vascularized and less swollen than in xiii.

Blood vascular system: The single, median, anteriorly narrowing dorsal vessel was traced forward on to the pharynx. It gives off a commissural vessel on each side in each of segments iv to xii but not in xiii and more posterior segments. In all these vessels the commissural vessels were seen to connect the dorsal vessel with the ventral vessel. In vi a slender vessel was seen to run forward from the lateral wall of the oesophagus to join the base of the commissural vessel on each side near the junction of the latter vessel with the ventral vessel. In vii a median vessel arising from a plexus on the floor of the oesophagus was present in addition to the lateral vessel and joined the commissural vessel at the same point. Supra-oesophageal vessels are present on the dorsal surface of the gut in viii to xiii. Their arrangement was particularly clearly seen in viii and ix where it seemed, with the exceptions noted below, to be typical. In each of the latter segments, three longitudinal vessels are present; the median of these runs through the entire length of the segment, that of viii being continuous with that of ix, while the vessel on each side arises from the median vessel posteriorly in the segment and runs the length of the segment but possibly ends at the anterior septum. From each of the paired supra-oesophageal vessels there arises an intra-mural peri-oesophageal vessel and, nearer the base, a vessel which connects with a ventrolatero-oesophageal vessel which runs on each side of the gut through segments iv (where it disappears in the posterior face of the pharynx) to x. In x the branch from each of the paired supra-oesophageals to the ventrolatero-oesophageal vessel appears to constitute the origin of the latter vessel which is not represented further posteriorly. In xii and xiii, in the absence of the ventrolatero-oesophageals, the branches from the paired supra-oesophageals which supply them in the more anterior segments send conspicuous branches to the posterior septa. The supra-oesophageals have connections with the dorsoventral commissurals in xi and xii. Here each commissural vessel has two roots, one from the dorsal vessel and the other from the paired supra-oesophageal vessel. In xii the latter root is the larger. In v and vi, at least, the ventrolatero-oesophageals receive vessels from the gut wall. In xiv posteriorly, in each segment, the dorsal vessel receives ventrally two pairs of vessels from the gut.

Nephridia: Septum 4/5 was dissected away from the pharynx and found to be clothed on its anterior face with dense clusters of robust meronephridia. Two bands of meronephridia were seen anterior to this; the posterior band appeared to belong also to septum 4/5 and the anterior and to the vestigial septum 3/4. Thus nephridia apparently begin in iii. The anterior face of septum 5/6 is densely clothed with coiled closed mero-nephridia only where the septum meets the parietes; nephridia are absent from the body wall and from the posterior face of septum 4/5. The conditions vi to xi is similar but in xi the nephridia impinge on the body wall adjacent to the posterior septum more than elsewhere. In xii and posteriorly this trend is taken further; there are no nephridia on the septa, the nephridia appearing sparsely in a band on the parietes posteriorly. By xiv the nephridia have become equatorial. At the posterior end of the body micro-meronephridia occur in a single equatorial band in each segment, except ventrally near the nerve cord where there is a patch of several on each side. In front of the latter in each segment there is a megameronephridium on each side.

Anterior male organs: No testes, sperm masses, sperm funnels or vasa deferentia were seen. A very large finely divided mass dependent on each side from the posterior face of septum 11/12 and filling xii anteroposteriorly appears to be a seminal vesicle and, in the absence of vesicles in ix or elsewhere, perhaps indicates metandry.

Posterior male organs: The prostate glands open to the exterior in xviii. The glandular portion is discoidal and its surface is much divided although there are no distinct lobes. The duct is short and stout. Transection of the gland entally shows that the greater part is a spongy mass with no macroscopic lumen but ectally reveals several macroscopic ducts.

Penial setae: Absent.

Female organs: Not visible.

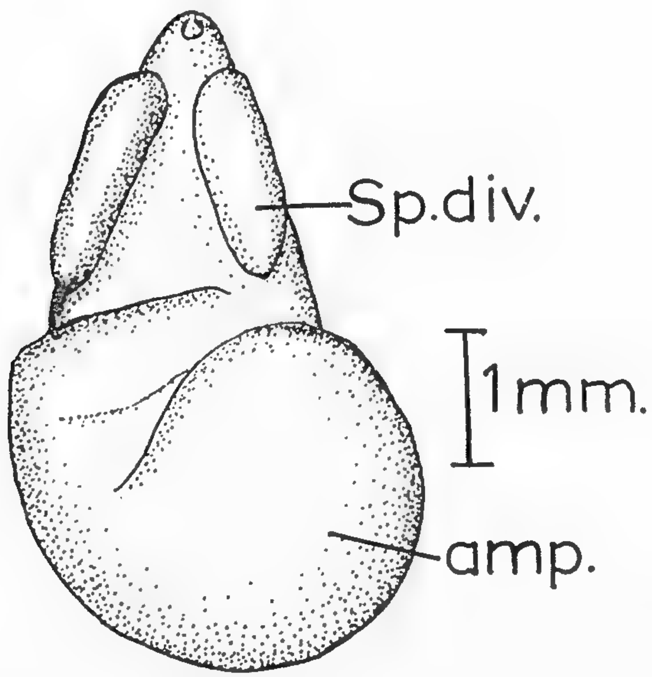

Fig. 5: *Digaster longmani.* Right hand spermatheca from segment viii of specimen W.3669 a. amp., spermathecal ampulla; sp. div., spermathecal diverticulum.

Spermathecae (fig. 5): A pair in each of vii, viii and ix (only the last two in most specimens, see above). Each has the form of a flattened sac tapering to the pore. The tapering portion constitutes a duct which is fairly clearly demarcated from the rounded ental region, the ampulla, of the spermatheca. The ectal third of the duct is attached ventrally to the body wall. The duct bears dorsally two approximately ovoid elongated diverticula, one on each side, which adhere to the duct through almost its whole length and converge towards the pore. The six spermathecae show a similar form. Each is ca. 5 mm. long.

Remarks

The above account, based on new material, largely confirms the type-description of Boardman (1932). Some points of divergence of the specimens examined from the types are as follows: they display gigantism, exceeding 5 feet in length; the prostomium is usually zygolobous; setal distance ratios are generally confirmed but *bc: aa* averages 0·4 in the fore-body, not 0·8, and *cd: ab* averages 1·5 behind the clitellum, not 2·3; the clitellum is longer, extending onto xiii and xix; the genital field is less clearly defined; accessory genital markings in viii to xii are not developed; the female pores are sometimes diagonally orientated; and two out of six specimens examined have an extra pair of spermathecal pores, in furrow 6/7.

On p. 90 affinities of *D. longmani* with *D. lamingtonensis* are discussed.

Digaster minor Spencer 1900

Fig. 6

Digaster minor Spencer 1900. *Proc. roy. Soc. Victoria, 13* pt. 1, pp. 65-66, fig. 100, 101, 102.

Type locality: Gayndah, Queensland (see material examined, below).

Material Examined: Approximately 13 badly preserved fragments, of which four are head ends. Three of the latter had been severed by an intraclitellar cut and showed no male fields. The missing fields were not detected in other fragments. The fourth head end included segment xviii and had been previously dissected. National Museum, Melbourne, registration: "*Digaster* sp. 2 Q", scrub behind Gayndah, Queensland, October, 1891, No. G.100, W. Baldwin Spencer Collection.

These specimens were labelled at the National Museum consecutively to specimens which appear to be typical material of *G. gayndahencis.* They accord with the type description of *G. minor* Spencer 1900 and entered Spencer's collection from the type locality of this species before publication of the type description. They do not conform with the type description of *G. brunneus* Spencer 1900, the types of which are missing, and they are here regarded as typical material of *D. minor.* The previously dissected specimen is probably the holotype.

Morphological Data

Unless otherwise indicated, these data are from one of the previously undissected head ends only.

Dimensions: Greatest width (in the forebody) 3·2 mm.

Secondary annulation: Slight, or absent from all specimens.

Colour: Pigmentless straw colour in alcohol with the clitellum pigmented light brown.

Prostomium: Epilobous, almost tanylobous, the peristomium being very short.

Setae: Black and distinctly visible, although not large. Apparently uniform. Some were not discernible in ix and ratios were taken from vii.

In segment vii $cd:ab = 2{\cdot}2$; $bc:aa = 1{\cdot}3$; $dd:u = 0{\cdot}6$ (one specimen).

Clitellum: Annular except in xiii where it is developed only dorsally, between setal lines *b*. In the previously dissected specimen it embraces xiii to xvii. Ventrally in xiv it shows a whitish area (a female genital field?) which extends from the anterior border to the equator of this segment and just includes the ventral setae.

Male genital field: Present only in the previously dissected specimen. A depression on each side at the site of the absent ventral setae of xviii appears from internal examination to mark the position of the prostate pores. In front of them a slight glandular development of the ventral surface of the segment is visible as a whitish area extending as far as intersegmental furrow 17/18.

Female pores: Not seen. Presumably on the glandular field in xiv described above.

Spermathecal pores: Not visible.

Dorsal pores: The first distinct pore is in furrow 7/8 but there is perhaps a suggestion of a pore in 6/7.

Internal characteristics:—

Septa: 6/7 fairly thin; 7/8 to 11/12 slightly thickened; 12/13 thinner. The condition of the more anterior septa is indeterminable.

Alimentary canal: Muscular, antero-posteriorly rather short gizzards are present in vi and vii. The gut otherwise is not sufficiently well preserved to provide useful data.

Blood vascular system: Indeterminable.

Nephridia: Micromeronephridia are visible in some anterior segments at least as far forward as the brain.

Anterior male organs: Well-developed racemose seminal vesicles lie on the anterior face of septum 9/10 and the posterior face of septum 11/12. No testes or funnels are visible.

Posterior male organs: Missing from the specimen examined. In the previously dissected specimen they are racemose with short ducts.

Penial setae: Absent.

Female organs: Septum 12/13, the posterior septum present, shows no gonads.

Spermathecae (fig. 6): In viii and ix, consisting of an ovoid ampulla and a sharply differentiated though fairly short duct, about a third as long, which bears ectally a many-lobed dorsal diverticulum.

Remarks

The above account, based on the syntypes, confirms and greatly extends Spencer's type-description. The accessory glandular patch in xix, noted by Spencer, was not seen in the re-examination, however. It is clear that Spencer erroneously interchanged the words " posterior " and " anterior " in his description of the seminal vesicles.

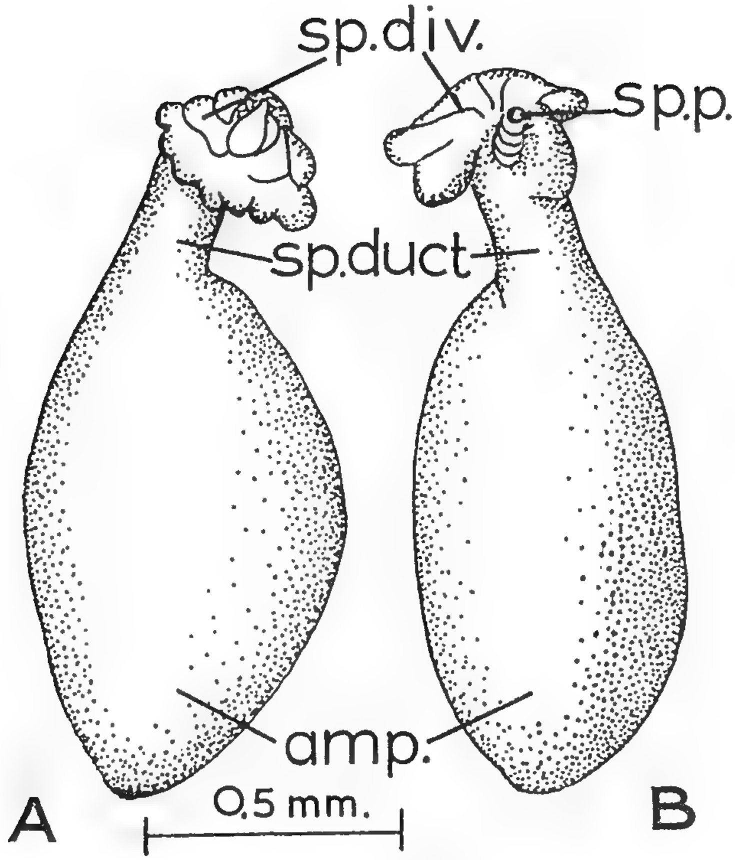

Fig. 6: *Digaster minor.* A spermatheca of a syntype. A, dorsal. B, ventral view. amp., spermathecal ampulla; sp.div., spermathecal diverticulum; sp.duct, spermathecal duct; sp.p., spermathecal pore.

Digaster perrieri Fletcher 1888

Fig. 7

Digaster Perrieri (sic) Fletcher 1888. Notes on Australian Earthworms. Part V. *Proc. Linn. Soc. N.S.W.*, *3*, (2), pp. 1,530-1,532.

Digaster perrieri; Michaelsen 1900. Das Tierreich, Lief. 10, p. 197.

Type-locality: Springwood, Blue Mountains, N.S.W. (25 spirit specimens, see Material Examined, below).

Material examined: Approximately 25 worms labelled " *Digaster Perrieri* (Valley Heights and Springwood) ", Australian Museum Reg. No. W.1325. Most of the specimens are clitellate and are either surface-hardened and shrunken or badly softened. Of seven well-preserved aclitellate specimens, four were opened and were found to conform with Fletcher's description of *D. perrieri*, as did a single clitellate specimen which was examined. Presumably this material is the type-series.

Morphological Data

Unless otherwise stated, these data are derived from a single specimen, W.1325, a.

Dimensions: Length 45 mm., greatest width (midbody) 3·5 mm.

Number of segments: 154.—*Colour:* Pigmentless buff.

Prostomium: Epilobous 1/3.

Setae: Apparently uniform, the lateral pair more widely spaced than the ventral pair.

In segment ix *cd: ab* = 1·7; *bc: aa* = 0·8; *dd: u* = 0·5; in segment xxv *cd: ab* = 1·4; *bc: aa* = 1·0; *dd: u* = 0·6 (one specimen, W.1325, 1).

Clitellum: Not developed.

Male genital field: This consists of three transverse ridges or tubercula pubertatis. The middle ridge occupies the setal annulus of xviii while the anterior and posterior ridges extend from this annulus almost to the setal zones of segments xvii and xix respectively. The three ridges extend laterally to mid *bc*. The anterior and posterior ridges are thus intersegmental. They bifurcate at their lateral extremities but the intersegmental furrow is otherwise absent from their surfaces. Setae *a* are present on the middle ridge, and at the site of the absent seta *b* on each side there is a dark point which is the penial seta projecting at the male pore. The anterior and posterior ridges bear a transverse linear series of minute white points the nature of which is obscure.

Female pores: Not visible.

Spermathecal pores: These are visible as paired small wart-like whitish swellings just laterad of setal lines *a* on the extreme anterior border of segments viii and ix and projecting into intersegmental furrows 7/8 and 8/9.

Dorsal pores: The first pore lies in intersegmental furrow 11/12 (specimens a and b).

Internal characteristics:—

Septa: Septa 2/3 to 5/6 are visible though very thin, and perhaps only 5/6 is complete; 6/7 to 11/12 are fairly thick and the remaining septa become successively thinner.

Alimentary canal: There is a gizzard in each of segments v and vi. In specimen a there are three gizzards, the anterior one being short and less well developed. Two further specimens, b and c, have gizzards only in v and vi, while a fourth specimen, (W.1325, d; prepared longitudinal sections placed in the Australian Museum) has three well-developed gizzards, in v, vi and vii. The latter specimen was identified as *D. perrieri* conclusively by examination of the general morphology and of the penial setae (see fig. 7 and remarks).

In specimen a the oesophagus in x to xiii has paired lateral pouches, each of which is highly vascularized and is supplied with a vessel from the dorsal vessel. Horizontal transection of these pouches in xi and xii revealed thick walls formed by folding of the wall of the pouch in such a way that numerous laterally radiating chambers are formed. These chambers appeared to be in some cases isolated by fusion of the inner extremities of the folds. In x a similar but less pronounced folding of the walls of the pouches is present while in xiii the walls were thick and possessed numerous constricted lumina. In xiv to xvi, although pouches are present, their lumina are not isolated from the oesophagus and only those in xiv show folding of the walls. The intestine does not conspicuously enlarge until xix but it begins to broaden anterior to this.

In specimen b the oesophagus, although vascularized, has no diverticula.

Blood vascular system: Hearts are present in xi to xiii and the dorsal blood vessel is unpaired.

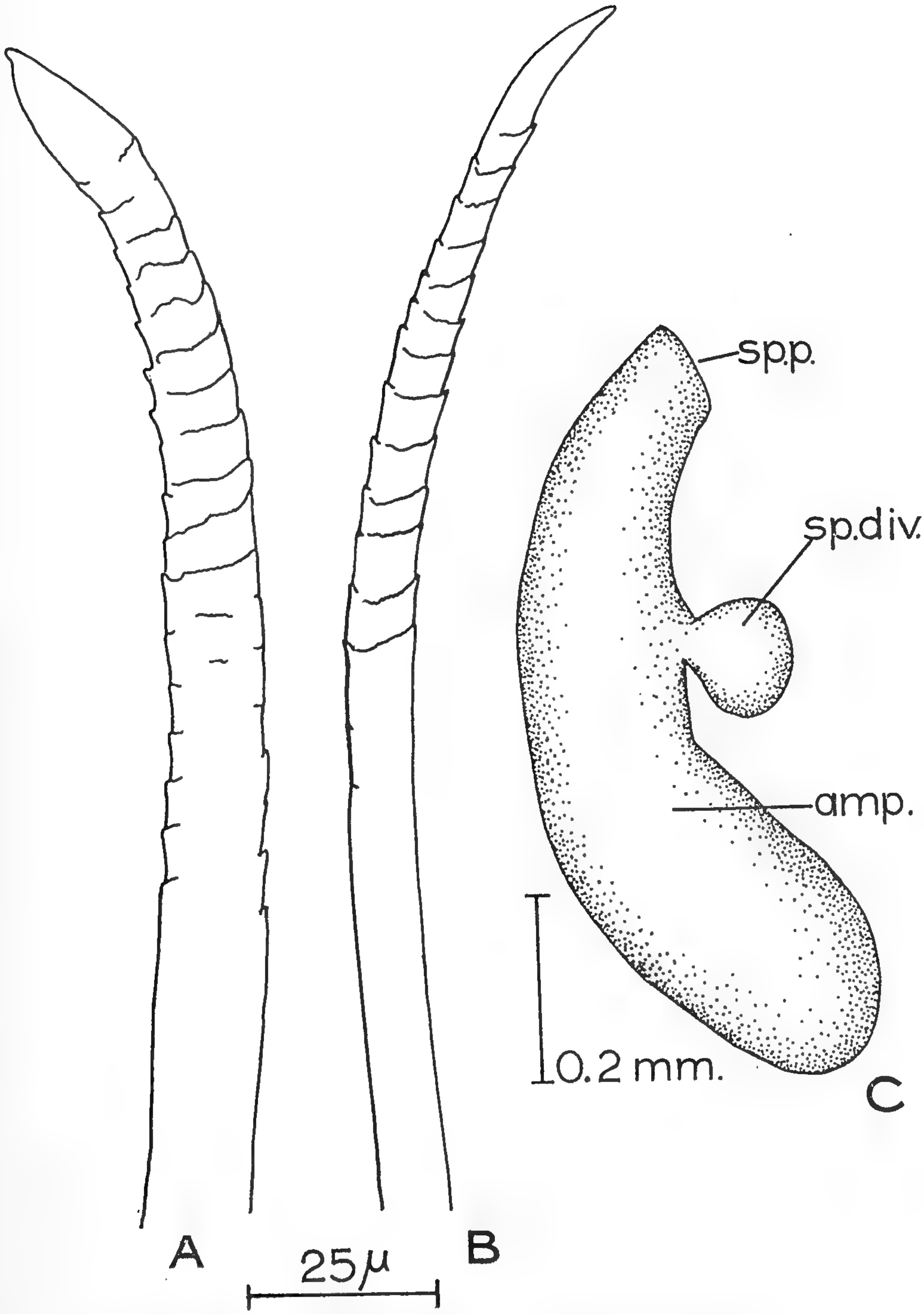

Fig. 7: *Digaster perrieri.* Ectal end of penial seta. A, of a digastric syntype, W.1325 b; B, of a trigastric syntype. C, right posterior spermatheca of specimen W.1325 b, *in situ.*

Nephridia: Micromeronephridia occur as far forward as iii. They are sparse in the forebody except in this segment in which they are apparently associate to form tufted nephridia. Behind xviii they are fairly numerous and are integumentary. An examination of the hindbody revealed no megameronephridia but about five micromeronephridia were seen on each side.

Anterior male organs: Shining seminal funnels were seen in x and xi and well-developed racemose seminal vesicles with very distinct lobes in xi and xii. No seminal vesicles occur in ix.

Posterior male organs: A racemose tongue-shaped prostate gland in xviii discharges to the exterior on each side by a slender shorter duct. What appeared to be a male duct was seen joining the ental end of the right prostate duct.

Penial setae: In specimen W.1325, b, and in the trigastric specimen a right penial seta is slightly curved in a single plane at the extremities. The ectal end tapers gradually to a point and bears a series of irregular encircling ridges except at the tip.

Length 0·9 mm., 0·6 mm., width ental to the ornamentation 15 mm. and 13 mm. respectively.

Female organs: Undeveloped.

Spermathecae (fig. 7): The spermathecae have each the form of an elongated sac the ectal portion of which constitutes a poorly demarcated duct. The duct bears a single finger-like diverticulum towards the ental end (W.1325, a). The spermathecae of W.1325, b, are fairly similar but the part of the duct ectal to the more rounded diverticulum is longer (fig. 7). Spermathecae in the specimens dissected from other localities are similar.

Remarks

Fletcher gave only a very brief account of this species which, he stated, agreed with *D. armifera* in general characters. The above account, based on material which almost certainly belongs to the type-series, confirms the similarity to *D. armifera,* except in the position of the last hearts. The penial setae are described and figured for the first time. Affinities between it and *D. armifera* and *D. nemoralis* are discussed on p. 88.

The significance of the occurrence in two specimens of three gizzards is discussed on p. 87. That both specimens conform with *D. perrieri* in general features and identity was conclusively demonstrated in one by examination of the penial setae. A sagittal half, a penial seta, and longitudinal serial sections of the latter trigastric specimen are in the collections of the Australian Museum.

Acknowledgements

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AN ACCOUNT OF COLLECTIONS OF FROGS FROM CENTRAL NEW GUINEA

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(Figs. 1 and 2) (Plates 1–5) Manuscript received 20.6.62

Summary

In an account of frogs in the Australian Museum collected in Central New Guinea, two new Hylid species (*Nyctimystes disrupta* and *N. foricula* from the Schrader Mountains), and one new Ranid (*Rana jimiensis* from the Jimi River Valley) are described. Variations within the paratype series are reported, and the relationships of the species are discussed.

Series or individual examples of four additional species of the genus *Nyctimystes*, four *Hyla*, three *Rana*, and one *Cophixalus* are represented, and notes on their morphology, ecology, parasites, distribution and vernacular nomenclature are included.

The representation of the family Microhylidae by a solitary specimen is discussed, and assumed to indicate selective rather than representative sampling of the herpetofauna by the collectors.

Introduction

In 1954, Mr. E. L. Troughton and Mr. N. Camps, of the Australian Museum, visited the Central Highlands of the Australian Trusteeship Territory of New Guinea, and collected a large number of specimens of animals which occur in that region, including several hundred frogs. A few specimens were also obtained near the Jimi River, north of the Central Highlands. Additional specimens from the Central Highlands were collected by Dr. R. N. H. Bulmer (currently of the Department of Anthropology, The University of Auckland) in 1955 and 1959. Dr. Bulmer also collected frogs in the course of anthropological field work in the Kaironk Valley of the Schrader Mountains in 1959 and 1960, and subsequently presented his collections to the Australian Museum.

The present paper is a composite account of the frogs obtained by Troughton, Camps and Bulmer. Three species are new to science, whilst the records of a further three species which have not been previously found in the Trusteeship Territory provide valuable supplements to the existing knowledge of their distribution. Amongst the Troughton/Camps collection are approximately 60 specimens of *Hyla* whose specific identity remains undetermined, and which have therefore been excluded from the present paper. It is hoped to include identifications in a taxonomic revision of the New Guinea Hylidae which is being currently undertaken by the author.

Collecting Localities

(A) *Troughton and Camps*

(1) *Wahgi Valley:* Detailed geographical notes and sketch maps of the Wahgi Valley have been prepared by Mayr and Gilliard (1954) and the author (1963).

(2) *Jimi River.*

(B) *Bulmer*

(1) *Mount Hagen Range:* Bulmer conducted anthropological research at Yaramanda on the northern slopes of the Mount Hagen Range in 1955, and returned to the same camp in September, 1959. Frogs were collected on each occasion.

Yaramanda is situated at an altitude of 5,000 feet near the source of the Baiyer River. The valley through which this river flows is approximately six miles wide, and extends in a direction which is almost due north. The Baiyer tributaries are within a few miles of a break in the Central mountains known as the " Hybrid Gap ", which was so named by Mayr and Gilliard (*supra. cit.*), who discovered that it had a profound influence upon the distribution of avian populations. Its probable influence upon the distribution of amphibians is discussed in the present paper. The Hybrid Gap is a region of grassland approximately 12 miles wide, and provides direct communication between the Baiyer River Valley and the Wahgi Valley.

(2) *Schrader Mountains:* The Schrader Mountains are situated approximately 50 miles north of the Wahgi Valley, and are separated from the Bismarck Mountains by the Kaironk Valley. Bulmer spent five weeks in the Upper Kaironk Valley from January to February, 1960, and collected numerous frogs during this period. Detailed maps of this area have yet to be prepared, and the following geographical information has been obtained from mimeographed ethnographic notes made by Bulmer, and an account of the valley by his colleague, Dr. B. Biggs (1960).

The Upper Kaironk refers to that portion of the valley which is east of the Mudubul River, and comprises an area of 20–25 square miles. The valley walls rise from 8,000 to 9,000 ft. on the north, and from 7,000 to 7,500 ft. on the south. The elevation of the valley floor varies from 5,000 to 6,400 ft. The valley walls are covered with tall grasses, interspersed with *Casuarina* groves to 6,500–7,000 ft., above which they are heavily forested. Views of the Kaironk River and the valley walls are depicted in Plates 1 and 2.

Shade temperatures recorded in February at 5,600 ft. did not exceed 75° F., whilst the minimum temperature experienced at night was 58° F. Rainfall in the same period was estimated to be in the vicinity of 40 inches.

Methods

With few exceptions the methods of description employed in the present paper conform closely to current herpetological practice. This particularly applied to the genus *Nyctimystes*, where the presentation of data follows the pattern used by Zweifel (1958), and the descriptions of palpebral pigmentation and fractional expressions of interdigital webbing comply with that author's definitions.

The following abbreviations have been used: TL (tibia length); S-V (snout to vent length); E-N (distance between anterior corner of eye and posterior margin of external naris); IN (internarial distance). Unless otherwise stated, the specimen references are the Australian Museum catalogue numbers.

SPECIES REPRESENTED

Family: **Hylidae.**

Hyla angiana Boulenger.

Hyla darlingtoni Loveridge.

Hyla iris Tyler.

Hyla montana Peters and Doria.

Nyctimystes daymani Zweifel.

Nyctimystes disrupta sp. nov.

Nyctimystes foricula sp. nov.

Nyctimystes humeralis (Boulenger).

Nyctimystes kubori Zweifel.

Nyctimystes narinosa Zweifel.

Nyctimystes semipalmata Parker.

Family: **Microhylidae.**

Cophixalus ateles (Boulenger).

Family: **Ranidae.**

Rana arfaki Meyer.

Rana grisea Van Kampen.

Rana jimiensis sp. nov.

Rana papua Lesson.

ACCOUNT OF SPECIES

Family: **Hylidae**

Hyla angiana Boulenger

Hyla angiana Boulenger, 1915. *Ann. Mag. nat. Hist.* 16 (8), p. 402.

Specimens: 18 adult males, 5 adult females, 1 juvenile. R. 14703, 14713, 14714, 14733, 18002–18006, 18051, 18075, collected by Troughton and Camps at Tomba, Mount Hagen in August, 1954; 14864, 14869, 16553, collected by Bulmer at Yaramanda, Baiyer River, in November, 1959; 15905, 15906, 15908, 15914, 15919, 15922, 15924, 15925, 15929, 15933, collected by Bulmer at the Kaironk Valley, Schrader Mountains, during the period February 5–17, 1960, at an altitude of 5.000–6,000 ft.

Diagnosis: A relatively large species (males <57 mm., females <78 mm.). The head is broad and strongly depressed with widely spaced nares and a short E-N distance. The fingers are approximately one-third webbed and the toes, with the exception of the fourth, are webbed to the disks.

Description of specimens: There is a close similarity in the TL/S-V and the E-N/IN ratios which, in the present series, are 0.52-0.65 and 0.53-0.67 respectively. The snout-vent length ranges are: males 46.6-57.0 mm., females 58.5-69.2 mm., juvenile 40.6 mm. The largest male slightly exceeds the maximum previously recorded for this sex.

There are no significant morphological differences between the present specimens and material from the Wahgi-Sepik Divide which has been discussed recently (Tyler, 1963).

Comments: Several vernacular names were found to be applied to this species in the Kaironk Valley: "*as gonjengk*", "*as kwangk*", "*as saky*", "*as kambamun*" and "*as akok*".

Hyla darlingtoni Loveridge

Hyla darlingtoni Loveridge, 1945. *Proc. biol. Soc. Wash.*, 58, p. 53.

Specimens: 1 adult male, 4 adult females, 19 juveniles: R. 14743-14747, 18055-18066, 18071-18074, collected by Troughton and Camps at Korn, Mount Hagen, in August, 1954; 14868, 14873, 16558, collected by Bulmer in the Baiyer River region in September, 1955.

Diagnosis: A moderately sized species (males: < 43.7 mm., females < 50 mm.) with outer fingers three-quarters webbed (continuing to the disk as a fringe); tympanum only slightly less than the diameter of the eye, and a distinctive yellow and black colour pattern in the groin and on the posterior surface of the thighs.

Description of specimens: The series conform very closely to the description of the types, and exhibit only slight variation in finger webbing. The smallest juvenile has a snout-vent length of 24.3 mm., and the mean of the immature specimens is 27.7 mm.

Comments: The interesting feature is the high proportion of juveniles. Of a series of 24 specimens collected by the author in the Wahgi Valley in March, 1960 (Tyler, 1963) only one specimen was sexually immature: a male with a snout-vent length of 29 mm. (British Museum, Nat. Hist., cat. No. 1961.1127). Immature tadpoles were observed during the same period, and it is therefore most unlikely that the juveniles (which were believed to be much larger than transformation size), could have developed

from spawn laid at the same breeding period. The mean size of the juveniles in the present collection which were taken in September, and comparison with the previous material, suggest that *H. darlingtoni* may take two years to reach sexual maturity. Alternatively, there may be more than one spawning period each year.

The native vernacular name in the Baiyer River region was found to be "*mungki papokole*".

Hyla iris Tyler

Hyla iris Tyler, 1962. *Rec. S. Aust. Mus.*, 14 (2): 253.
Specimen: A single adult female (R. 14749) collected by Troughton and Camps at Korn, Mount Hagen.

Diagnosis: A multi-coloured, pygmy species with maximum snout to vent lengths of 31 mm. for males, and 38 mm. for females. The outer finger is webbed to the disk.

Description of specimen: The present specimen has a snout-vent length of 32.2 mm., and agrees very favourably with the Australian Museum paratype series (R. 16832-16836), with which it has been compared. In view of this conformity and the availability of the recent description of the species, further comments are excluded from the present account.

Hyla montana Peters and Doria

Hyla (*Litoria*) *montana* Peters and Doria, 1878. *Ann. Mus. Stor. Nat. Genova*, 13, p. 423.
Specimen: 1 gravid female (R. 15931), collected by Bulmer at the Kaironk Valley, Schrader Mountains, in February, 1960.

Diagnosis: A relatively large species in which the head is broader than long, the vomerine teeth are usually situated directly between the choanae, the outer finger is approximately one-third webbed, and crenulated dermal folds extend along the posterior surface of forearms, whilst a row of tubercles is present on the tarsus.

Description of specimens: The single representative of *montana* differs from the type description in few respects. The vomerine teeth are in two short and slightly oblique series directly between the choanae; the outer finger is one-third webbed, and the toes are webbed to the disks (the fourth has only a very narrow fringe on the sides of the penultimate phalanx). There is a crenulated fold on the posterior surface of the forearm, a row of tubercles on the posterior surface of the tarsus, and a few tubercles around the arms and on the heel.

In alcohol the dorsal suface is an immaculate dark-brown. There is a pale-blue triangular patch on the upper lip at the angle of the jaws, and there are a few small, faint blue spots on the side of the body. The ventral surface is dull yellow-brown, and the tubercles are white.

Nyctimystes daymani Zweifel

Nyctimystes daymani Zweifel, 1958. *Amer. Mus. Novit.* 1896, p. 8.

Specimens: 33 adult males, 3 adult females and one juvenile: R. 14700, 14701, 14705, 14718, 14719, 14724, 14725, 14732, 14741, 17998-18001, 18009, 18013, 18020-18022, 18024-18027, 18034-18037, 18047, 18049, 18052, 18054, 18068, 18069, 18078, 18079, 18081, 18082, collected by Troughton and Camps at Manjim, Ganz River, in July and August, 1954; R. 14876 collected by Bulmer at the Baiyer River on August 23, 1955.

Diagnosis: (As defined in the type description). Veins of palpebral reticulum orientated in near-vertical direction with few horizontal connections. Internarial distance distinctly less than distance from eye to naris. Legs relatively short (TL/S-V mean = 0.51). Size relatively small: largest of males measures 42 mm. from snout to vent.

Description of specimens: Measurements of this fine series are recorded in table 1. The E-N/IN and TL/S-V ratios encompass and exceed those of the type series, and the means are slightly lower and higher respectively.

TABLE 1.—Measurements of **Nyctimystes daymani**

	S-V		TL/S-V		E-N/IN	
	Range	Mean	Range	Mean	Range	Mean
Males (33) ..	40.1-46.0 mm.	44 mm.	0.50-0.57		1.05-1.43	
Females (3) ..	44.0-53.5 mm.	48 mm.	0.52-0.56	0.54	1.03-1.30	1.19
Juvenile (1) ..	30 mm.		0.54		1.08	

The interdigital webbing conforms to that of the type, and all specimens possess the small dermal heel lappet and row of tubercles on the outer edge of the forearm. Only six specimens exhibit a dorsal colouration resembling that of the type, and the remainder are grey, sparsely spotted with small black marks on the body and, to a lesser extent, on the limbs. Zweifel (1958) does, however, state that there is considerable variation in the colouration of the paratypes. The appearance of the majority of the present series bears a resemblance to Zweifel's illustration of *N. fluviatilis* Zweifel, a species known from a single specimen which has close affinities with *daymani*. The *fluviatilis* type has E-N/IN and TL/S-V ratios which are within the range of the present series, but the other morphological characteristics of the latter material are more closely allied to *daymani*. There is a possibility that *daymani* and *fluviatilis* are in fact conspecific, but this cannot be ascertained until further specimens are obtained from regions between the widely separated type localities.

Comments: *N. daymani* has not been found previously in the Australian Trusteeship Territory.

Nyctimystes disrupta sp. nov.

Holotype: An adult female (R. 15923) collected by Dr. R. N. H. Bulmer at an elevation of 6,000 feet in the Kaironk Valley, Schrader Mountains, Australian Trusteeship Territory of New Guinea, on February 4, 1960.

Diagnosis: A species with a close affinity to *N. papua*, but clearly distinguished by more extensive webbing between the fingers, and a palpebral venation which, although disrupted, is far more pronounced than in that species.

Description of holotype: Vomerine teeth in two short, heavy, slightly oblique series lying directly between the large rounded choanae; tongue almost two-thirds as wide as mouth opening, broadly oval, its posterior border free and rounded; snout large, slightly rounded in profile; nostrils more lateral than superior, projecting, their distance from end of snout about one-third that from eye, separated from each other by an interval equal to about two-thirds their distance from eye. Canthus rostralis

well defined. Eye large, very prominent, its diameter equal to its distance from nostril; inter-orbital distance slightly greater than width of upper eyelid, which is relatively wide and slightly greater than distance between nostrils. Palpebral venation consists of numerous broken lines with a tendency to predominate in the vertical plane. Tympanum very distinct, about one-third the diameter of eye; separated from eye by a distance greater than its own horizontal diameter.

Fourth finger two-thirds webbed, others half-webbed, fourth longer than second, just reaching to disk of third which completely covers the tympanic area; metatarsal tubercles weakly developed; suggestion of a slight tarsal ridge; no dermal appendage on heel. Body not elongate, in post-axillary region a little narrower than greatest width of head; when hind leg is adpressed, heel reaches beyond tip of snout; when limbs are laid along the sides, knee and elbow considerably overlap; when hind legs are bent at right-angles to body, heels overlap slightly. Skin of upper parts minutely granular, a few small tubercles occur above and below tympanum; strong glandular ridge extends from position just behind eye to above insertion of forelimb, encircling the tympanum; skin of throat and anterior part of pectoral girdle smooth, that of remainder of ventral surface of body and femurs uniformly granular. Skin of head not co-ossified with skull.

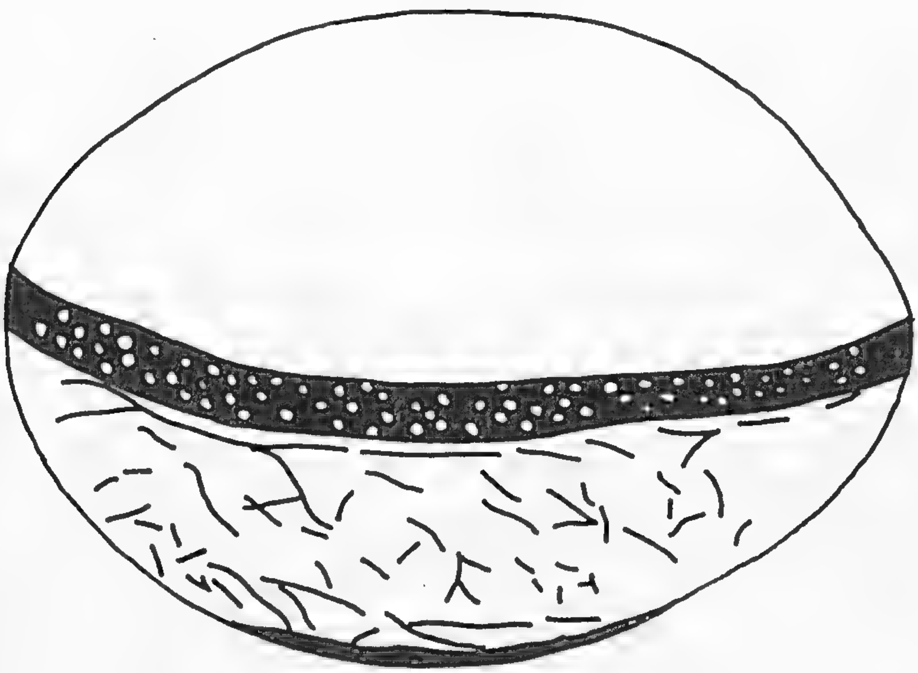

Fig. 1: Palpebral venation of *Nyctimystes disrupta*

Colour in alcohol of dorsal surface of head, body and limbs deep violet, with a few circular spots of white colour up to 2.5 mm. in diameter scattered upon them. Ventral surface of limbs, hands and feet pale copper; abdomen lilac; throat copper marbled with lilac. Photographs of holotype appear on Plate 3.

Dimensions of Holotype: Snout-vent 70 mm.; head length 23 mm.; head width 21 mm.; tibia 40.5 mm.

Variation: The paratype series consists of two adult females (R. 15916, 15921) taken at the type locality on February 5, 1960, and an adult male (R. 16600) collected at an elevation of 5,000 feet at the Baiyer River on October 4, 1959. Both female paratypes are smaller than the holotype, and the snout-vent length of the male is 46 mm. The distance between eye and naris is greater than the internarial span in all specimens.

The E-N/IN ratio range is 1.15-1.31, and the mean is 1.20. The tibiae of the male are relatively longer than those of the holotype and other paratypes, having a TL/S-V of 0.61, but the range is only 0.56-0.61, and the deviation from the mean of 0.58 is therefore not considerable.

Basic colour in alcohol is similar to that of the holotype, but all exhibit irregular lighter or darker patches upon the dorsal surface, whilst the white spotting is also constant.

In addition there are three badly distorted specimens, tentatively assigned to *disrupta*. These are R. 14862 and R. 14865, collected at Yaramanda (5,000 feet) on the western side of the Baiyer River, on November 21, 1955, and September 11, 1955, respectively; R. 15910 collected at the type locality on February 3, 1960. Field notes accompanying R. 14865 describe the colour in life as follows: " Back dark olive, legs mottled dark grey. Under-surface of legs translucent quartz, belly pink-mauve. Iris light olive."

Comparison with other species: The most salient feature which characterizes *disrupta* is the palpebral venation, and the only species approaching it in this respect is *papua*.

The British Museum cotypes of *papua* were examined by the author and, when certain specimens in that series had been rejected as not conspecific, the remainder were found to have a palpebral venation consisting of a few isolated dots (Tyler, 1963). In additional material these dots occasionally form a few scattered lines, but each line is invariably composed of a series of dots in close proximity to one another. The venation of *disrupta* is far more prominent, as seen in Figure 1. *N. disrupta* may be more clearly distinguished from *papua* by the degree of webbing of the hands. In the new species the outer finger is two-thirds webbed, and the other fingers are at least one-half webbed. *N. papua* has only one-quarter to one-third webbing. Although the TL/S-V ratios overlap (*papua:* 0.51-0.58; *disrupta:* 0.56-0.61), the E-N/IN ratios are distinct (*papua:* 0.89-1.12; *disrupta:* 1.15-1.31), and the difference between the minimum TL/S-V ratio of *papua* and the maximum of *disrupta* (0.42) is far greater than that within any single species currently known. Although Zweifel (1958) has reported geographic trends in E-N/IN and TL/S-V ratios of *N. montana*, no similar trends have been found in *papua*.

N. disrupta has an identical TL/S-V ratio to that of *semipalmata* as defined by Zweifel (*loc. cit.*), but lacks the large dermal appendage of that species, has a lower E-N/IN ratio, and an entirely different colouration. *N. semipalmata* is sympatric with *disrupta* in the Schrader Mountains, and is clearly distinct.

The head proportions and size of *disrupta* are very similar to *montana*. The latter species has a palpebral venation consisting of numerous vertical lines with a few horizontal connections; usually possesses a heel tubercle; has a higher TL/S-V mean, and entirely different colouration. *N. montana* has not been found within 350 miles of the Schrader Mountains.

Native vernacular name: " *mungki kunkupis,*" for the Baiyer River paratype. Bulmer also recorded in his field notes the name, " *äs binfok,*" which means, " red woman ".

Nyctimystes foricula sp. nov.

Holotype: An adult male (R. 15904) collected by Dr. R. N. H. Bulmer at an altitude of between 5,000 feet and 6,000 feet in the Kaironk Valley, Schrader Mountains, Australian Trusteeship Territory of New Guinea on February 4, 1960.

Diagnosis: A medium-sized species with TL/S-V and E-N/IN ratios which are shared by *N. kubori*. It differs from that and all other known species in possessing a very dense palpebral venation which only permits light to enter via a few narrow slits which are obliquely situated.

Description of holotype: Vomerine teeth in two short, transverse series lying close together and directly between the small, rounded choanae. Tongue one-half as wide as mouth opening, oval, its posterior border free and notched; snout rounded when viewed from above, slightly rounded in profile; nostrils more lateral than superior, their distance from end of snout about one-third that from eye, separated from each other by an interval almost equal to their distance from eye. Canthus rostralis slightly defined, loreal region oblique. Eye large, prominent, its horizontal diameter greater than its distance from nostril, interorbital distance slightly less than width of upper eyelid, which is relatively wide and greater than internarial span. Lower eyelid with a heavy palpebral venation of broad oblique veins. Tympanum distinct, about one-third the diameter of eye, separated from eye by a distance greater than its own diameter.

Fourth finger half-webbed, others webbed at base, third longer than fourth; disk of third covers the tympanic area; toes (with exception of fourth) fully webbed, the web on fourth toe reaching the middle of the penultimate phalanx, disk of fourth covering the tympanic area; a poorly developed, thin tarsal ridge, and a more marked ridge on outer edge of forearm and fourth finger; no dermal appendage on heel. Body rather elongate, in post-axillary region approximately three-quarters the greatest width of head; when hind leg is adpressed, heel reaches beyond tip of snout; when limbs are laid along the sides, knee and elbow overlap considerably; when hind legs are bent at right angles to body, heels overlap slightly.

Skin of upper parts smooth; a rather narrow but clearly defined supratympanic ridge extends from behind posterior corner of eye to above insertion of forelimb; skin of throat minutely granular, chest, abdomen and lower femur uniformly and more coarsely granular; vocal sac internal with long paired slit-like openings on floor of mouth. Large nuptial pad on inner surface of first finger. Skin of head apparently not co-ossified with skull.

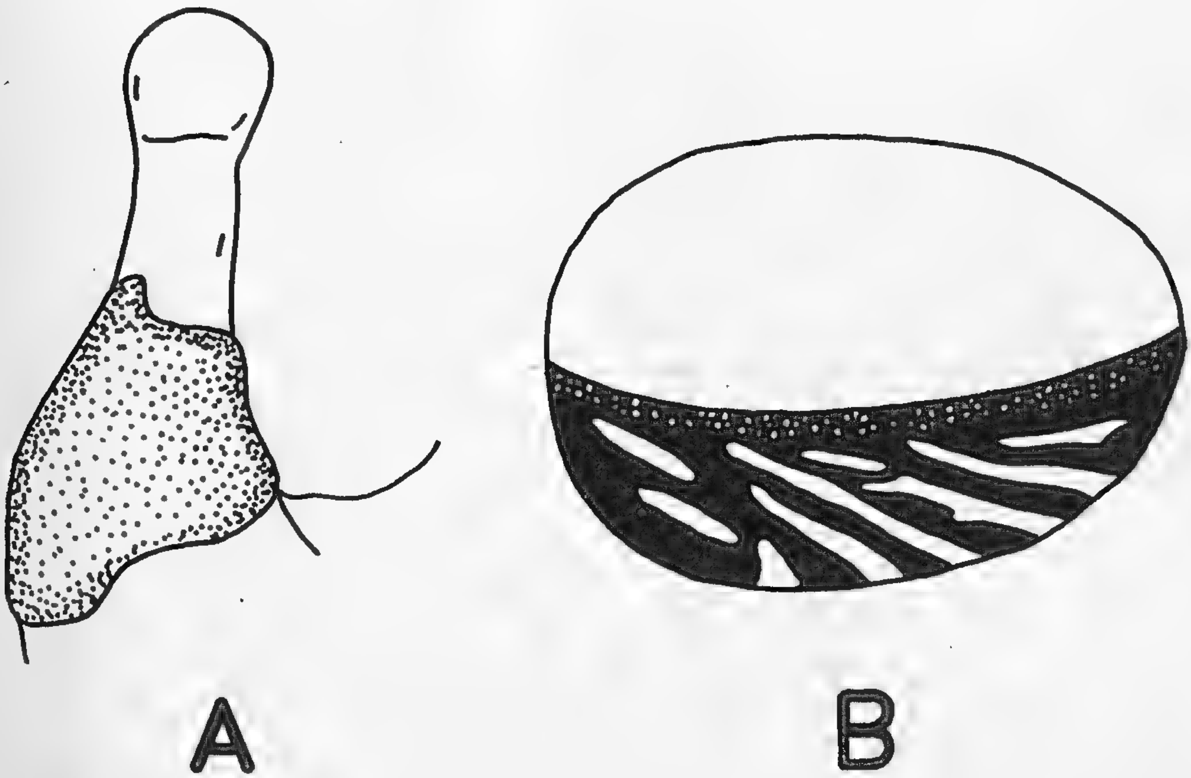

Fig. 2: *Nyctimystes foricula.* A, nuptial pad; B, palpebral venation

Colour in alcohol of dorsal surface of head, body and those portions of limbs probably exposed when living creature at rest, a pale blue. Ventral surface of body and limbs, and dorsal surface of humerus pale yellow. Upper lip bordered with white.

Dimensions of Holotype: Snout-vent 38 mm.; head length 13 mm.; head width 14 mm.; tibia 21 mm.

Variation: The paratype series comprises four adult males (R. 15909, 15918, 15926, 15928) collected at altitudes of between 5,000 feet and 6,000 feet at the type locality, between February 4 and 6, 1960; one gravid female (R. 15911) collected at 5,700 feet on February 3, 1960.

There is little variation in the size of the male paratypes. The smallest (R. 15909) has a snout to vent length of 35 mm., and the largest (R. 15926) one of 38 mm. The single female measures 52 mm. The distance between eye and naris of this specimen and four of the males is slightly greater than the internarial span. The exception (R. 15928) is only slightly less, with an E-N/IN ratio of 0.96. The mean for the entire series is 1.04, and there is probably no significance in the exception. The TL/S-V range of 0.52-0.59 is also very limited, and the mean is 0.56.

The paratypes are in an excellent state of preservation, and it is unlikely that the extent of the finger webbing differs appreciably from that found in living specimens. All of the finger disks of the female cover the tympanum. The appearance of the nuptial pad of the male (R. 15928) is depicted in Figure 2A.

The colouration of the paratypes is largely similar to the holotype. The pale blue dorsal surface of the body of R. 15909 is sparsely suffused with pale pink, and the head and body are finely stippled with black. Three specimens exhibit a narrow pink line which forms a margin at the termination of the dorsal colour, between axilla and groin. It is probable that *N. foricula* is green in life.

The ova of the gravid female are unpigmented and approximately 2.5 mm. in diameter.

Comparison with other species: The extensive palpebral venation of *foricula* (Figure 2B) will distinguish this species from all other known *Nyctimystes*. The only species with a venation approaching it is *kubori*, but the pattern of the latter forms a dense reticulum which lacks any directional orientation into lines. The TL/S-V and E-N/IN ratios of *kubori* are similar to those of *foricula*, but the two species may be distinguished by the following characteristics:—

The diameter of the tympanum of *kubori* is equal to the distance between tympanum and eye, whereas in *foricula* it is approximately one and one-half times the distance; the dermal fold on the forearm of *kubori* is broken into a row of tubercles, but is a continuous ridge in the new species; the snout of *kubori* is high, and the canthus rostralis sharp and quite distinct, but the snout of *foricula* is depressed, and the canthus rostralis only slightly defined; *kubori* is a slightly larger species which is brown in life and in alcohol.

Native vernacular name: Bulmer recorded the name of " *as gonjemai* ".

Nyctimystes humeralis (Boulenger)

Hyla humeralis Boulenger, 1912. *Zool. Jahrb.* 1, suppl. 15, p. 216.

Specimens: 6 adult males, 3 adult females, 1 immature female. R. 14694, 14695, 14702, 18043-18045 collected by Troughton and Camps at Manjim, Ganz River,

in July, 1954; 14863 collected by Bulmer at Yaramanda (5,000 feet) in the Baiyer River region on September 5, 1955, and 16550, 16551, 16582 taken at the same locality during the period September 30-October 18, 1959.

Diagnosis: A large species (maximum snout-vent length of males = 100 mm., and of females = 83 mm.) with an immaculate colouration. The males have a large projecting spine on the humerus, and two patches of prominent conical nuptial spines on the first finger.

Description of specimens: Males in the present series all possess the characteristic sexual characters mentioned in the diagnosis. The snout-vent lengths are as follows:—

males 71.8-89.5 mm.

females 50.3-83.6 mm.

The E-N/IN mean is 1.00, and the range 0.93-1.06, whilst the TL/S-V mean is 0.61 and the range 0.56-0.64. These means are respectively slightly lower and higher than those quoted by Zweifel (1958), but as the latter series included specimens which are now believed to represent a species close to *humeralis* but distinct from it (Zweifel, *in litt.*), no significance can be placed upon the deviation. A coloured sketch of a live specimen (R. 14863) depicts an immaculate pale green dorsal surface, with lemon-yellow margins on the outer surfaces of the limbs. The undersurface is shown to be a similar colour, and the toe webbing pale rust. The abdomen is said to be "yellow-green".

Comments: Despite the uniformity in the appearance of specimens in life, Bulmer recorded different vernacular names for the three specimens taken at the Baiyer River in 1955: "*mungki elambo,*" "*mungki lyambo*" (regarded as an alternative spelling of *elambo*) and "*mungki kunkupis*".

Nyctimystes kubori Zweifel

Nyctimystes kubori Zweifel, 1958. *Amer. Mus. Novit.* 1896, p. 18.

Specimens: 3 females, R. 15912, 15913, 15920, collected by Bulmer in the Kaironk Valley, Schrader Mountains, during the period February 3-5, 1960, at an elevation of between 5,000 feet and 6,000 feet.

Diagnosis: Palpebral venation forming a dense reticulum; outer fingers one-third webbed. Maximum size recorded: males 53 mm., females 58 mm.

Description of specimens: The E-N/IN range of 0.94-1.16 and TL/S-V range of 0.53-0.57 approximate those of the types. The appearance and other characteristics used in the determination conform closely to those defined by Tyler (1963), with the exception that the dorsal surface of R. 15912 is grey instead of brown.

Nyctimystes narinosa Zweifel

Nyctimystes narinosa Zweifel, 1958. *Amer. Mus. Novit.* 1896, p. 26.

Specimens: 8 adult males, 1 adult female, 1 immature female, 3 juveniles: R. 14704, 14715-14717, 14736, 14737, 18010-18012, 18083, 18084, 18099, 18100 collected by Troughton and Camps at Tomba, Mount Hagen in August, 1954.

Diagnosis: A relatively large species (males < 59.5 mm., females < 69.8 mm.) with slightly webbed fingers and extensively webbed toes. The distance between the nares is greater than that between eye and naris.

Description of specimens: All of the males exhibit secondary sexual characters, of which the nuptial pad conforms closely to the described shape (Tyler, 1963). None of the present specimens approach the maximum snout-vent length recorded, and their range is 48.3-53.8 mm. The TL/S-V range of 0.55-0.63 and mean of 0.59 are only slightly higher than those for the types. The range of E-N/IN is 0.78-1.00 and the mean 0.86, both of which also compare favourably with the type series.

The body proportions, palpebral venation and colouration of the three juveniles do not show any marked difference from the adults. The snout-vent lengths of 16.4 mm., 18.0 mm. and 20.0 mm. are the smallest yet known, and that of the first-mentioned is probably only slightly above transformation size.

Nyctimystes semipalmata Parker

Nyctimystes semipalmata Parker, 1936. *Ann. Mag. nat. Hist.*, ser. 10, 17, p. 83.

Specimens: One adult male (R. 14875), and one adult female (R. 16556) collected by Bulmer at the Baiyer River in 1955.

Diagnosis: A large species (maximum snout-vent length of females 84 mm.) with a high E-N/IN ratio (mean 1.34—Zweifel), and a large triangular dermal lappet on the heel.

Description of specimens: The mature female conforms to the rediagnosis of Zweifel (1958), and has a snout-vent length of 79.4 mm. The TL/S-V and E-N/IN ratios of 0.63 and 1.55 respectively are slightly higher than the known ranges but, as those were based on only six specimens, the differences probably lack significance.

The male is badly damaged, but is referred to *semipalmata* on the evidence of the following features: the extremely broad head; a TL/S-V ratio of 0.603, and E-N/IN ratio of approximately 1.6; the large heel lappet and the colour pattern.

Comments: This is the first record of the occurence of *N. semipalmata* in the Australian Trusteeship Territory. The present locality is approximately midway between the widely separated previous records of Idenburg River (Dutch New Guinea), and south-east Papua in the vicinity of Kokoda, the type locality.

Family: **Microhylidae**

Cophixalus ateles (Boulenger)

Sphenophryne ateles Boulenger, 1898. *Ann. Mus. Stor. nat. Genova,* 38, p. 708.

Specimen: A single specimen collected by Bulmer at Yaramanda during the period October-December, 1959.

Diagnosis: A very small species, adult from approximately 15 mm. snout-vent length; may be distinguished from all other known members of the genus, except *shellyi* Zweifel, by its extremely short first finger.

Description of specimen: This specimen is rather distorted as a result of dehydration, so estimates of ratios involving a high degree of accuracy have been ommitted. The S-V length is approximately 15 mm.

The dorsal surface is grey, lightly stippled with black. The side of the head beneath the canthus rostralis, the lateral margin of the upper eyelid and the lower half of the tympanum are black. The dorso-lateral surfaces of the body are grey with sparse, irregularly-shaped black markings, whilst the limbs are spotted with black. The ventral surface of the body is brown, densely flecked with white, grey and black.

Comments: Details of the examination of part of the *ateles* type series have been published elsewhere (Tyler, 1963).

Family: **Ranidae**

Rana arfaki Meyer

Rana Arfaki Meyer, 1874. *Monatsb. Akad. Wiss. Berlin*, p. 138.

Specimens: 2 adult females: R. 14710, 18050 collected by Camps at the middle Jimi River in July, 1954.

Diagnosis: A very large species with a maximum snout-vent length of approximately 200 mm. Dorso-lateral dermal folds on the body are either weakly developed or absent. Outer metatarsals are almost entirely separated from one another. Finger and toe disks are only slightly dilated.

Description of specimens: The two specimens collected by Camps were both partially deviscerated in the field to ensure satisfactory fixation. The snout-vent lengths are 142 mm. and 98 mm. respectively, and the specimens conform very closely to the description of van Kampen (1923).

The vomerine teeth are in two feebly curved oblique series between the semi-circular choanae. The tympanum is almost circular in shape, and has a diameter which is approximately one-half and two-thirds of the eye diameter respectively. When the hind limbs are held at right-angles to the body, the heels overlap. The TL/S-V ratios are 0.58 (R. 14710) and 0.63 (R. 18050). Further details of these specimens are included on page 126, where they are compared with the new species of *Rana*.

Comments: This is the first record of the occurence of *R. arfaki* in the Australian Trusteeship Territory.

Rana grisea Van Kampen

Rana grisea Van Kampen, 1913. *Nova Guinea*, 9 (3) p. 460.

Specimens: 5 adult males, 13 adult females, 7 juveniles: R. 14709, 14712, 14720, 14730, 14738, 14739, 18007, 18008, 18017-18019, 18070, collected by Troughton and Camps at Manjim, Ganz River, in July, 1954; R. 14861, 14877, collected by Bulmer at Yaramanda, Baiyer River, in August, 1955; R. 16557, 16566-16570, 16598, 16599, 16611, collected at the same locality in October-November, 1959; R. 15917, 15927, collected by Bulmer at the Kaironk Valley, Schrader Mountains, in February, 1960.

Diagnosis: The possession of a first finger longer than the second, a lateral groove between the superior and inferior surfaces of the digital disks, and widely separated dorso-lateral, glandular dermal folds will distinguish *R. grisea* from other New Guinea species with the exception of *R. papua*. The diagnostic characters separating *grisea* from *papua* are discussed in the account of the former species by Parker (1936).

Description of specimens: The characteristic features of *grisea* have received considerable attention: Van Kampen (*loc. cit.*), Parker (*supra cit.*), Loveridge (1948), Tyler (1963). The present description is therefore largely concerned with variation within the Australian Mûseum material.

Eight of the females have snout-vent lengths exceeding 80 mm. The range is 63.0-87.5 mm., and the mean is 79 mm. The males range from 59 mm. to 68 mm., and their mean is 62.2 mm.

The distance separating the dorso-lateral, glandular folds at the occiput is equal to the distance between the naris and (*a*) a point midway between the posterior corner of the eye and the tympanum (7 specimens); (*b*) a point nearer to the

tympanum than the eye (7); (*c*) the anterior border of the tympanum (8), or (*d*) the anterior half of the tympanum (2). The tympanal diameter varies from slightly less than one-third to two-thirds of the eye diameter, and the two are separated by a distance which is equivalent to one-half of the tympanal diameter (15), or greater than one-half but less than three-quarters (10).

Comments: Loveridge (1948) described the sub-species *R. grisea milneana* from Milne Bay in south-east Papua. His diagnosis is apparently a comparison between that type and the description of the type of *grisea*. Although inferred in the description of the *milneana* type, the complete webbing between the toes is by no means unique for, in Van Kampen's (1923) definition of *grisea* it is stated: " toes entirely webbed or two phalanges free." As it is impossible to distinguish *milneana* from *grisea* by means of the remaining information supplied, it is suggested that present evidence is insufficient to warrant the continued recognition of *milneana*.

A large proportion of the series were infested with various parasites. Four specimens were hosts to larvae of the dipterous parasite *Batrachomyia* sp. (Family: Chloropidae), situated sub-dermally on the dorso-lateral surface near the glandular folds. The outer muscle walls of several digestive tracts were found to be infested with large numbers of Cestode cysts, whilst Nematodes and immature Trematodes were recovered from within the ilea. One frog (R. 16568) was infested by a leech situated subcutaneously on the dorsal surface of the body.

Bulmer found that the native vernacular names applied to this species of frog were " *mungki alu* " and " *mungki kwikyelo* " at Yaramanda, whilst " *as tyembas* " was the name used in the Kaironk Valley.

Rana jimiensis sp. nov.

Holotype: A gravid female (R. 14711) collected by Mr. N. Camps at Manjim, Ganz River, on July 16, 1954.

Diagnosis: A large species, with a snout-vent length of 100 mm., distinguished from other Papuan *Rana* by its blunt snout, tubercular skin and a small tympanum whose marginal annulus is partially obscured by tubercles. The tibiae are short, and the finger and toe disks markedly dilated.

Description of holotype: Vomerine teeth in two slightly oblique series extending considerably behind the small slits of the choanae; tongue cordiform and deeply notched on posterior margin. Head broader than long; snout abrupt when viewed from above, truncate in profile; canthus rostralis prominent and slightly rounded, loreal region oblique and concave; nostril nearer to tip of snout than to eye. Inter-orbital space less than breadth of upper eyelid, with a shallow groove extending along the occiput. Tympanum indistinct, the annulus being partially obscured by epidermal tubercles, tympanal diameter approximately one-third the diameter of eye. Disks of fingers clearly defined, and very prominent sub-articular tubercles are present; fingers in decreasing order of length $3 < 4 < 1 < 2$. Toes with large disks, each of which have a horizontal diameter approximately three times greater than the breadth of the penultimate phalanx; webbing extending to the disks of all toes except fourth, where it is present as a fringe on the penultimate phalanx; outer metatarsals separated to the base; sub-articular tubercles prominent, inner metatarsal tubercle large and oval, outer metatarsal tubercle smaller, but prominent and rounded. No tarsal fold. When hindlimb is adpressed along side of body, heel reaches beyond tip of snout; when hind-limbs are held at right-angles to body the heels just meet.

Dorsal surface of head, body and limbs strongly rugose, particularly on upper eyelids. No dorso-lateral glandular skin folds, but a few short, thin longitudinal

plicae behind head forming no particular pattern, and a short, weak supratympanic fold. Ventral surface minutely granular.

Dorsally a uniform dark brown. Throat, pectoral region and upper abdomen cream, heavily mottled with dark brown. Lower abdomen and hindlimbs creamish-yellow, lightly marked with brown. Dorsal and lateral views of the holotype may be seen in Plates 4 and 5.

Dimensions of Holotype: Head and body 100 mm.; head length 35 mm.; head width 42 mm.; femur 50 mm.; tibia 55 mm.; foot 52 mm.; hand 32 mm.

Comparison with other species: The slender habitus of five of the six species of *Rana* currently recognized as valid for the Papuan region (Loveridge, 1948), prevents any confusion with *jimiensis*. The only species bearing a remote resemblance is *R. arfaki*, but may be distinguished from it by the difference in head proportions. In specimens of *arfaki* sympatric with *jimiensis*, the distance between the anterior corner of the eye and the middle of the tip of the snout is one and one-half of the horizontal eye diameter, whereas in *jimiensis* the distance is only one and one-quarter of the eye diameter. Similarly, the longer head of *arfaki* may be expressed by comparison of the breadth of the head immediately posterior to the eyes, and the distance between the tip of the snout and the posterior corner of the eye. In *arfaki* this head measurement is greater than the snout-eye distance, but in *jimiensis* it is less than it.

As mentioned above, the exact tympanum diameter cannot be accurately determined due to the presence of tubercles upon a portion of each annulus, but the diameter is no more than one-third of the eye diameter, and it is separated from the eye by a distance equivalent to one and one-third of its own diameter. In *arfaki* the tympanum is distinct, and between one-half and three-fifths of the eye diameter, from which it is separated by a distance equal to its own diameter.

The tibia of *arfaki* is distinctly greater than the distance between the head of the femur and the mid-ventral line, but only just equal to it in the new species. The relative size of digital disks, the presence of an outer metatarsal tubercle in *jimiensis*, the appearance of the skin, and the colouration of the two species leave no doubt that they are quite distinct from one another. Parker (1936) commented upon the fact that specimens of *arfaki* from Kokoda in Papua possessed much smaller tympani than those from elsewhere, and therefore agreed closely with *R. waigeensis* van Kampen, which is considered to be a synonym of *arfaki*. Parker's material was, however, stated to fall within the limits of variation recorded for *arfaki*; the present specimen does not.

Rana papua Lesson

Rana papua Lesson, 1830. *Voyage Coquille*, Zool. 2 (1) p. 59.

Specimens: 2 adult males: R. 14708, 14748, collected by Troughton and Camps at the middle Jimi River in July, 1954.

Diagnosis: A species closely allied to *R. grisea* and distinguished from it by relatively narrower dorso-lateral glandular folds, and a shorter distance between eye and tympanum in relation to the tympanal diameter.

Description of specimens: The specimens have snout-vent lengths of 73 mm., and 50 mm. respectively. The distance between the dorso-lateral glandular folds is equal to the distance from the naris to the posterior corner of the eye. The tympanum is separated from the eye by a distance which is equal to approximately half the horizontal tympanal diameter.

The colouration of the dorsal surface of the body of R. 14748 is similar to the description prepared by Loveridge (*loc. cit.*). Much of the head and back of R. 14708 is grey, but this is believed to be an artefact which has occured after preservation. The ventral surface of the latter is an immaculate white, and R. 14748 is only faintly marked with brown on the throat.

Comments: The status of the Ranid frogs *grisea*, *papua*, *kreffti*, *daemeli* and *noveabrittanae* has been the subject of much discussion and considerable confusion. Whilst not disputing the distinction of *grisea* and *papua*, it is suggested that the currently recognized sub-species are inconsistently founded, and without adequate supporting biological evidence.

The present locality record is the first in the Central Highlands region.

Discussion

A rather unusual feature of the collections is the great variety of Hylid species, but the presence of only a single representative of the Microhylidae. That there are numerous Microhylid species in the moss-forests on the mountain slopes bordering the Wahgi Valley has been established (Tyler, 1963), which suggests that the lack of such material in the Troughton/Camps collection simply reflects the nature of the environments in which specimens were taken (i.e., at altitudes below the moss-forests, in areas where the Hylidae and Ranidae are known to dominate the Anuran fauna). No less than four of the five Hylid species which they collected were at that time undescribed, whilst a further two were only known from type series.

The representation of the Microhylidae by a single specimen in the collection made by Bulmer in the Schrader Mountains, may be only partly referred to environmental conditions. The grass-covered slopes would certainly be unsuitable for Microhylids which tend to exhibit preferences for less exposed areas at such altitudes. It must, however, be borne in mind that Bulmer was primarily interested in vernacular zoological nomenclature, and a bias towards collecting frogs which are eaten by, and therefore familiar to, the natives is believed to have occurred. Few Microhylids attain a size large enough to be eaten. Although the Bulmer collection is unlikely to be truly representative, it is nevertheless extremely valuable.

Despite the fact that knowledge of the geographical distribution of New Guinea frogs is very limited, it is possible to establish that the Hybrid Gap is of more importance as a means of direct communication between the Wahgi and Baiyer River Valleys than as a barrier between the mountain ranges on either side. For example, *Hyla darlingtoni*, which breeds in static or slowly moving water, and which is therefore unable to exist upon the mountain slopes, is known to be prolific throughout the length of the Wahgi Valley. The record of this species in the Baiyer Valley extends its known distribution further north, and suggests that it is likely to occur in an uninterrupted chain throughout the numerous valleys leading to the Schrader and Bismarck Mountains. The valley floors have provided routes for the migration of *Rana grisea*. This species was assumed to be the only member of the genus in the Western Highlands region, and is apparently equally well established in both tropical lowland and sub-tropical highland areas throughout the island. The finding of *R. papua* in the Central Highlands is the first record in the Trusteeship Territory south of the Bismarck Mountains, whilst the appearance of *R. arfaki* and the new species at the Jimi River suggests that the area monopolised by *grisea* is a relatively restricted one.

Most of the remaining Hylid species in the present collection are only known from type series or two or three records. It is apparent, however, that *Nyctimystes* spp. are to be found in isolated communities whose locations are probably related to strict microclimatic preferences, within what appears to be a relatively uniform environment.

Until the taxonomy of the New Guinea Hylids and the variation of genotypic and phenotypic characters within the constituent species have been established, the presence of naturally occurring hybrids in the highlands cannot be determined with any degree of accuracy. It can be safely assumed that the gap between the Mt. Hagen Range and the Wahgi-Sepik Divide is an effective and complete barrier preventing migration between the mountains. As the environmental conditions on the gap are quite unsuitable for *Nyctimystes* and all *Hyla* but *darlingtoni*, the question of hybridisation at that point does not arise, and the description of the gap is inapplicable to amphibians.

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Dr. Biggs (Department of Anthropology, the University of Auckland) permitted reproduction of his photographs of the Kaironk Valley, whilst the plates of type specimens were prepared by Miss M. Boyce (South Australian Museum), and Mr. Howard Hughes (Australian Museum). Radiographic plates were prepared by Mr. J. Littler. I am deeply indebted to all these persons for the contributions they have made to the present paper.

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EXPLANATION OF PLATES

1. Kaironk River at approximately 5,000 feet a.s.l.
2. Middle Kaironk Valley. (Photographer facing east at an altitude of approximately 5,000 feet).
3. Left: *Nyctimystes disrupta*—top, ventral view of holotype (R. 15923); bottom, dorsal view. Right: *Nyctimystes foricula*—top, ventral view of holotype (R. 15904); bottom, dorsal view.
4. *Rana jimiensis*—dorsal view of type (R. 14711).
5. *Rana jimiensis*—ventral view of type (R. 14711).

Sydney: V. C. N. Blight, Government Printer—1963


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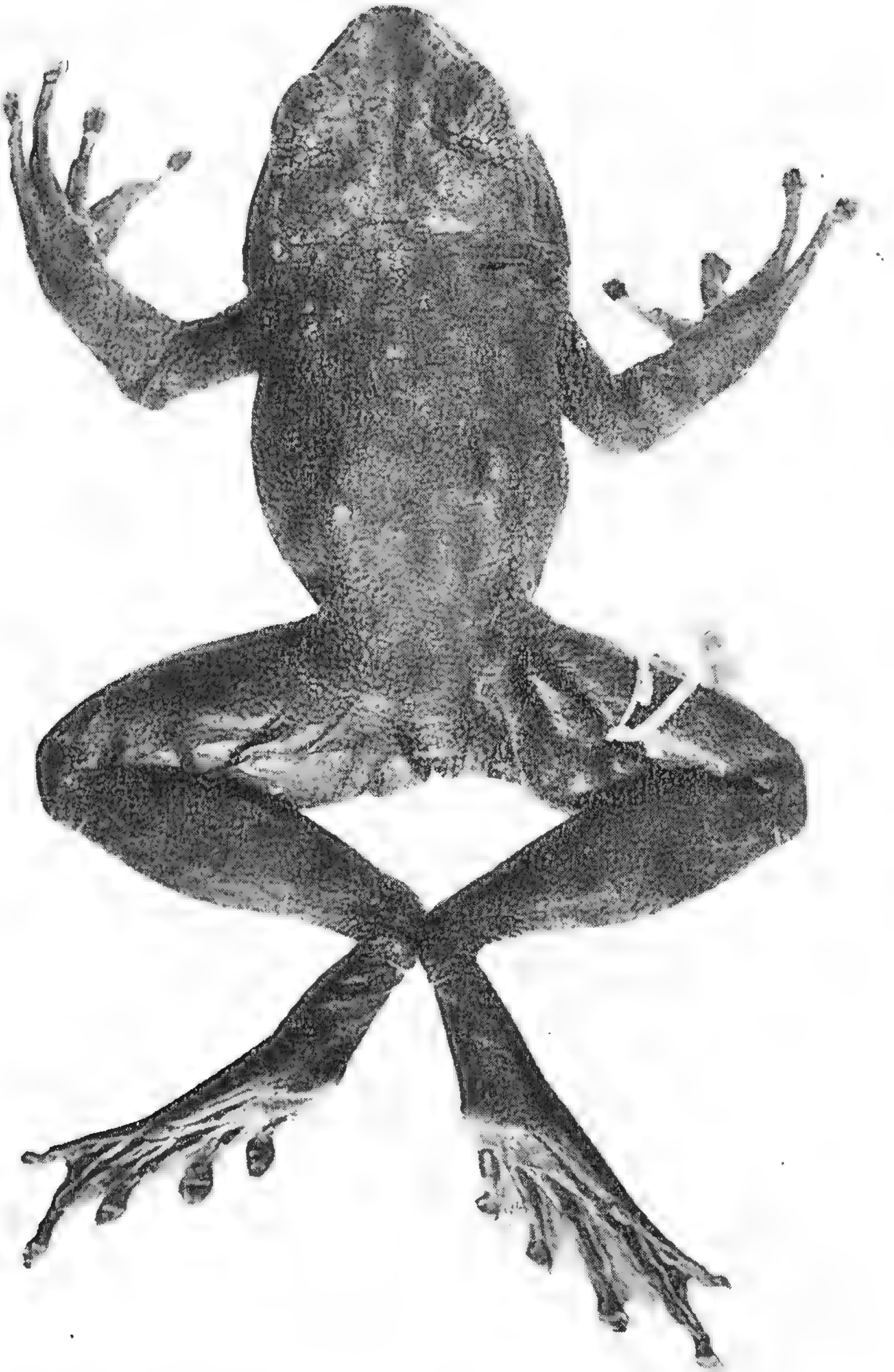

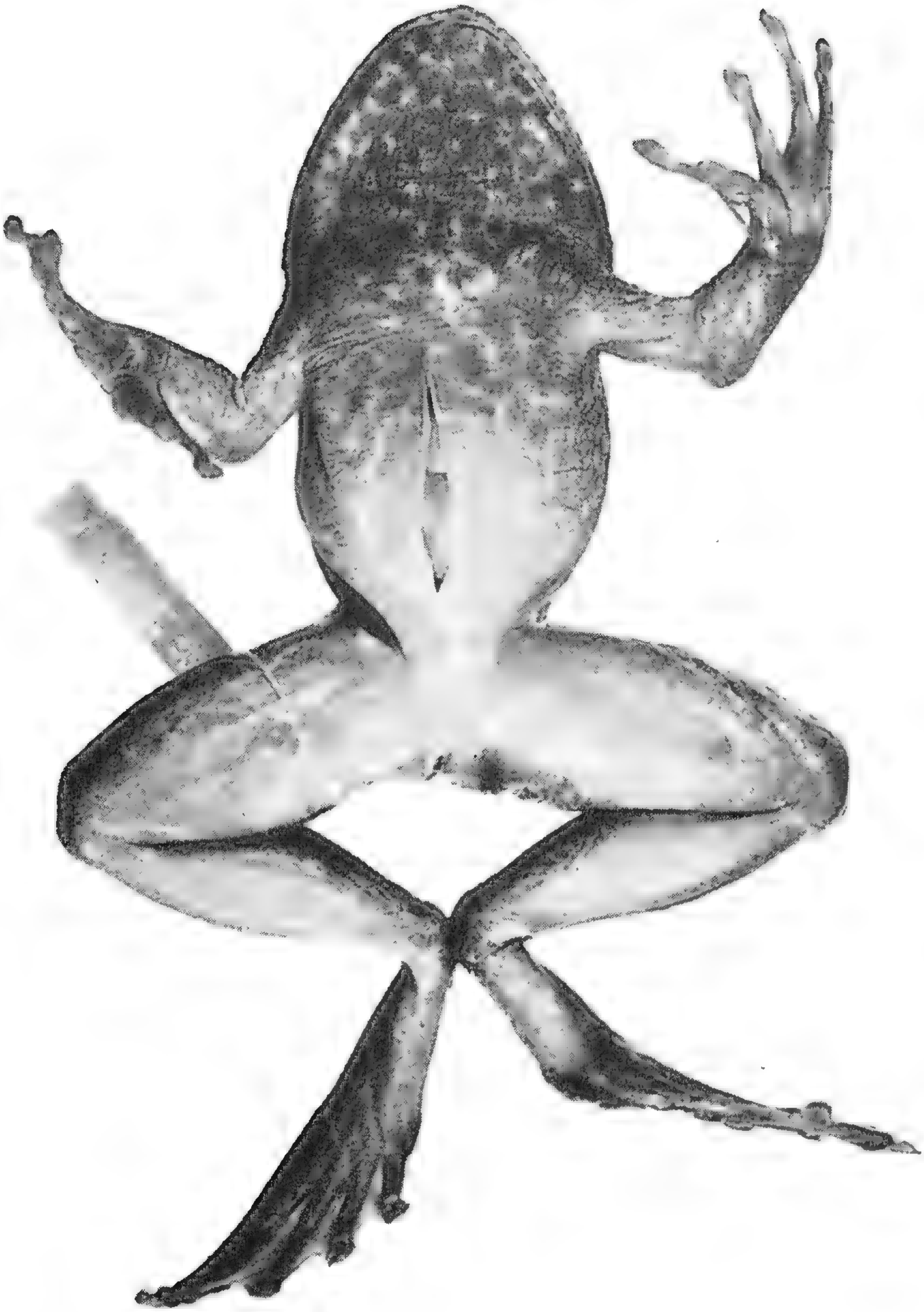

Redescriptions of the Australian Majid Spider Crabs *Leptomithrax gaimardii* (H. Milne Edwards) and *Paramithrax barbicornis* (Latreille)

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Plates 6 and 7. Figs. 1–14. Manuscript received 14.12.62.

ABSTRACT

Paramithrax gaimardii H. Milne Edwards, 1834, is redescribed and figured from photographs of the holotype. It is regarded as a species of *Leptomithrax* Miers, 1876, conspecific with *L. australiensis* Miers, 1876, and *L. spinulosus* Haswell, 1880. *Paramithrax barbicornis* (Latreille, 1825) is also redescribed and figured and is considered synonymous with *Gonatorhynchus tumidus* Haswell, 1880, following Balss (1929). This species was designated as the type of the genus *Paramithrax* H. Milne Edwards, 1834, by Desmarest (1858) and the genus *Gonatorhynchus* Haswell, 1880, is consequently reduced to synonymy with *Paramithrax*.

INTRODUCTION

In the first volume of H. Milne Edward's (1834) major work on the Crustacea a new species of oxyrhynch crab, *Paramithrax gaimardii*, supposedly collected in New Zealand waters by Quoy and Gaimard, was described, and placed in Section B of Milne Edward's new genus *Paramithrax*. Unfortunately, the description was hardly adequate enough to permit later identification of the species. Consequently, the only mention of this name in later literature was Miers's (1876a : 219) short description and misidentification of the species at present known as *Leptomithrax sternocostulatus* (H. Milne Edwards, 1851) as *P. gaimardii*, and Filhol's (1886 : 356) brief redescription of Milne Edward's original material. Fortunately, Miers's remarks on his *P. gaimardii* left little doubt as to which species he was actually referring, and the mistake was later corrected (Miers, 1879a).

In 1876 Miers (1876a: 219) divided the genus *Paramithrax* into two subgenera, *Paramithrax* (s.s.) and *Leptomithrax*. Included in the latter was a new Australian species, *L. australiensis*. In his description of this species Miers remarked that it bore a general resemblance to the new New Zealand species, *L. longimanus* (the preceding species), but " the carapace is covered with small spinules, and there are three or four larger spines on the branchial regions. Anterior legs shorter (than *L. longimanus*); hand slightly compressed and granulous at the base; palm about as long as the wrist. The whole animal is covered with short, stiff hairs curled at the tips " (Miers, 1876a: 220). No figure of *L. australiensis* was provided.

Haswell (1880a: 441, pl. xxv, fig. 3) described *Leptomithrax spinulosus* from material collected by Mr. Kendall Broadbent in Tasmania. It is interesting to note that this was the same locality from which Miers had earlier described *L. australiensis*.

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Unlike the descriptions of Milne Edwards and Miers, this was detailed and provided with a good figure. More than 20 years later Fulton and Grant (1906a: 6), after examination of the type specimens of *L. australiensis* and *L. spinulosus*, the former in the British Museum of Natural History and the latter in the Australian Museum, Sydney, were able to say that the two species were synonymous. Fulton and Grant further stated: " This view is upheld by a memorandum in the handwriting of the late Mr. E. J. Miers attached to specimens in the British Museum received in exchange from Sydney ". However, most later workers seemed to have missed this paper, the name *L. spinulosus* continuing to appear in the literature.

Rathbun (1918: 21) noted that Filhol (1886) in his description of *P. gaimardii* had observed that the hepatic spine was bifurcate and that there were five marginal branchial spines on the carapace. From this Rathbun suggested that " this species (*L. spinulosus*) may be the *L. gaimardii* of Milne Edwards ". In addition another good figure of *L. spinulosus* was provided. Hale (1927a) figured *L. australiensis* and added some information about the habits of the species. Comparison of the photographs of the holotype of *Paramithrax gaimardii* with the descriptions and figures of *Leptomithrax australiensis* and *L. spinulosus* and with photographs of the holotype of the former species leads me to the conclusion that all three are conspecific and should therefore be known in future as *Leptomithrax gaimardii.*

The identity of the Australian *Paramithrax barbicornis* (Latreille, 1825) presents a problem rather similar to that posed by the foregoing species, having been figured only once and never adequately described. Originally described as *Pisa barbicornis* it was placed in section A of the genus *Paramithrax* by Milne Edwards (1834), but transferred to a separate new genus, *Lobophrys*, by Filhol (1886: 360) after examination of a species from New Zealand, supposedly closely related to *P. barbicornis* and formerly confused with it. This New Zealand species was called *Paramithrax cristatus* by Filhol, apparently unaware that Miers (1876a: 219) had already given it the name *P. latreillei.*

In the Australian literature Haswell (1880a: 437, pl. xxv figs. 4, 4a) described and figured a new genus and species of crab, *Gonatorhynchus tumidus*. Like his description and figure of *Leptomithrax spinulosus* these were quite satisfactory for later identification and the name became widely established in Australian literature (Fulton and Grant, 1906b; McCulloch, 1913; Hale, 1927a). In his revision of the majid Brachyura, Balss (1929: 17, 18, pl. 1 fig. 4) was able to show from an examination of a photograph of Latreille's type of *P. barbicornis* that this species and *Gonatorhynchus tumidus* were one and the same and he therefore adopted the name *Gonatorhynchus barbicornis*.

Ward (1933) made an interesting and important point when he noted that Desmarest (1858) had designated *P. barbicornis* as the type of the genus *Paramithrax*. The following are Desmarest's own words: " *Paramithrax* Edw.: groupe ne renfermant qu'un petit nombre d'espèces particulières a l'Australasie, et dont le type est la *Pisa barbicornis* Latreille." (Desmarest, 1858: 14). Dr. John S. Garth, Allan Hancock Foundation, Los Angeles, and Dr. L. B. Holthuis, Rijksmuseum van Natuurlijke Histoire, Leiden, have both (pers. comm.) confirmed the validity of Desmarest's designation. Unfortunately, Ward's paper was missed by later workers and Miers's (1879b) designation of *Paramithrax peronii* H. Milne Edwards, 1834, as the type of *Paramithrax* has consequently been accepted by nearly all recent workers on the group. It would appear, however, that *Paramithrax barbicornis* is not congeneric with *P. peronii* and the other species at present referred to *Paramithrax*, and it is intended to discuss this point in more detail elsewhere (Griffin, 1963).

The remaining part of the present paper is devoted to a redescription, based on photographs of the holotype, of *Leptomithrax gaimardii*, a species widely known in Australian literature as either *L. australiensis* or *L. spinulosus*, and of the type species of *Paramithrax*, *P. barbicornis*, which is recorded in the Australian literature as *Gonatorhychus tumidus*.

The terminology employed in this paper is based on that used by Rathbun (1925: 1, figs. 1, 2), and the system of dimensions follows that of Garth (1958: 27).

SYSTEMATIC DISCUSSION

Genus **Leptomithrax** Miers, 1876

Leptomithrax gaimardii (H. Milne Edwards, 1834)

Text figs. 1-6; pl. 1 figs. 1, 2; pl. 2 figs. , 1.

Paramithrax gaimardii H. Milne Edwards, 1834: 325. Filhol, 1886: 356. Not *P. gaimardii* Miers, 1876a: 219 = *Leptomithrax stenocostulatus* (H. Milne Edwards, 1851).

Leptomithrax gaimardii, Rathbun, 1981: 18, 21.

Leptomithrax australiensis Miers, 1876a: 220. Haswell, 1880a: 440; 1882: 16. Fulton and Grant, 1906a: 6. Hale, 1927a: 135, fig. 135; 1927b: 311.

Leptomithrax spinulosus Haswell, 1880a: 441, pl. 25 fig. 3; 1882: 16. Rathbun, 1918: 20, pl. 9. Balss, 1935: 125.

Holotype: Female, length 107 mm., width 84 mm. (measurements supplied by J. Forest), Muséum National d'Histoire Naturelle, Paris. The photographs (pl. 1) show this specimen to be in a very damaged condition with most of the dorsal surface of the carapace broken and the abdomen and ambulatory legs missing.

Type locality: New Zealand; Quoy and Gaimard, collectors.

Types of Leptomithrax australiensis and L. spinulosus:—

L. australiensis: Holotype in the British Museum of Natural History, London (pl. 2). Female (B.M.N.H. Reg. No. 1962.7.19.1) length 76 mm., width 57 mm. (from photograph), a dry specimen in reasonably good condition with parts of some of the ambulatory legs missing. There is no locality label attached, but on a pin beneath the crab is a small blue label " *australiensis* Miers " in Miers's own handwriting (I. Gordon, pers. comm.).

L. spinulosus: A total of 11 syntypes in the Australian Museum, Sydney. A lectotype is here selected as follows:

Lectotype: Male [Aust. Mus. No. G.5116 (old No. A.5474)], length 71 mm., width 54.5 mm. (measurements by J. C. Yaldwyn), an undamaged, dry specimen mounted on glass with printed label " Type G.5116 *Leptomithrax spinulosus* Haswell. Loc. Tasmania " and hand-written label " 27. Tasmania. Type specimen. A.5474." Dr. J. C. Yaldwyn (pers. comm.) states that this specimen is almost certainly that on which Haswell's figure (Haswell, 1880a: pl. 25 fig. 3) and measurements were based.

Paralectotypes: The two dried females (A.5479 and A.5483) and presumably also a collection of eight specimens in spirit (A.5468, A.5482, A.5484, A.5497-8, A.5502-3), loc. Tasmania, coll. Mr. Kendall Broadbent. The status of a dry male specimen also in the collection of the Australian Museum, labelled " Type *Leptomithrax spinulosus*, Bass St., 30 fm." (Aust. Mus. No. P.11384) is unknown. There is no evidence that this was one of Haswell's syntypes.

Two specimens in the British Museum of Natural History, London (Aust. Mus. No. A.5470 and A.5490), in spirit in a jar with a label written in pencil, " *Leptomithrax spinulosus* Haswell, Loc. Tasmania ", are syntypes (now paralectotypes) of *L. spinulosus* Haswell, having been sent to the British Museum by the New South Wales Government for the International Fisheries Exhibition of 1883.

Localities subsequently reported: No specimens of this species have been recorded from New Zealand since that of Quoy and Gaimard, and, moreover, as the collections of Brachyura in New Zealand do not contain any specimens which might be regarded as belonging to this species, it seemes likely that the locality label of the holotype is incorrect. However, several workers have recorded this species from Australia (as either *L. australiensis* or *L. spinulosus*) as follows:—

King George's Sound, Albany, Western Australia (Haswell, 1882); Port Phillip and Bass Strait, common (Fulton and Grant, 1906a); numerous F.I.S. " Endeavour " stations from New South Wales to Eucla, including Tasmania (Rathbun, 1918); Beare's Point, Kangaroo Island, South Australia (Hale, 1927b); Oyster Harbour, Albany, Western Australia (Balss, 1935).

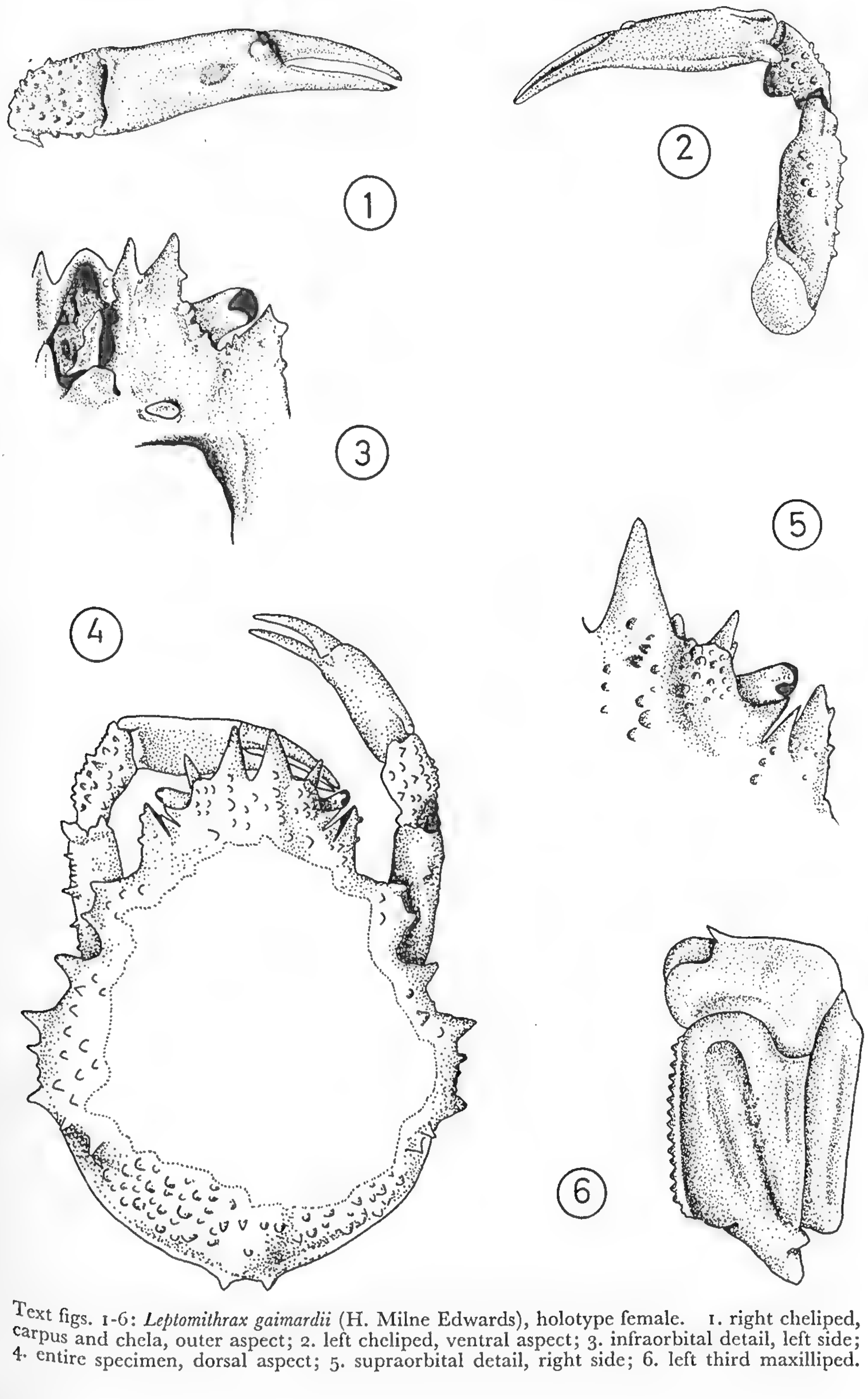
Distribution: South-east Australia, Tasmania, South and south-west Australia; common in Australian waters (Hale, 1927a).

Diagnosis: Carapace broadly pyriform, densely tuberculated dorsally, four prominent marginal branchial spines and several smaller spines. Rostral spines short, stout. Postorbital lobe with two subequal, more or less spinous, tubercles on posterior edge, one close to tip and one about one-third from base. Anterolateral spine of basal antennal article barely exceeding anteromedial spine in length, edges of article tuberculated. Outer maxillipeds swollen at union of ischium and merus but not conspicuously so.

Description: Carapace broadly pyriform in dorsal aspect (length approx. 1.3 times width), densely covered by tubercles dorsally, a row extending posteriorly from base of rostral spines on each side of midline at least as far back as level of postorbital lobe. Rostral spines short and stout, less than one-tenth length of carapace, elongate triangular in dorsal aspect, sharply-pointed. Hepatic margin with two short, widely spaced spines. Branchial margin bearing four prominent conical, subequidistant spines with several small spines or tubercles situated between these at a higher or lower level. Posterior intestinal margin with two short spines situated close together submedially. A larger medial tubercle close to posterior intestinal margin.

Orbit consisting above of supraorbital eave, intercalated spine and postorbital lobe, the three closely approximated and separated only by narrow deep fissures; supraorbital eave broad, sharply angled anteriorly, lateral edge straight posteriorly, dorsal surface tuberculated, a moderately long, acute spine at posterolateral corner; intercalated spine as long as posterolateral spine of eave, acute; postorbital lobe long, about one-and-a-half times as long as intercalated spine, broad-based, acute distally, anterior surface excavated to form a " cup ", a fringe of hairs surrounding margin of excavation, posterior edge of lobe bearing two prominent tubercles, one situated close to tip, the other about one-third from base, a smaller tubercle just basal to the latter. Orbit incompletely formed below by basal antennal article so as to leave eyestalk almost completely visible in ventral view. Eyestalk short, stout, not quite reaching postorbital lobe, bulbous basally; cornea large, subterminal, slightly ventral.

Interantennular spine well-developed, directed downwards, the sharply pointed tip weakly curved forwards.



Text figs. 1-6: *Leptomithrax gaimardii* (H. Milne Edwards), holotype female. 1. right cheliped, carpus and chela, outer aspect; 2. left cheliped, ventral aspect; 3. infraorbital detail, left side; 4. entire specimen, dorsal aspect; 5. supraorbital detail, right side; 6. left third maxilliped.

Basal antennal article broadly subrectangular, lateral edge with several small tubercles grouped close together along basal two-thirds, medial edge also with several tubercles, anterior angles bearing two strong, forwardly directed spines, the anterolateral one slightly longer and at a higher level than anteromedial and visible in dorsal view.

Outer maxillipeds moderately gaping. Ischium longitudinally sub-rectangular, medial edge coarsely toothed, medial half of distal edge abruptly extended anteriorly as a rounded process, outer surface excavated medially as a prominent, wide, shallow, longitudinal groove. Merus subquadrate, as wide as, but shorter than ischium, distal edge deeply notched, a prominent sharp spine at lateral angle of notch; junction of ischium and merus weakly elevated as a transversely oval area.

Chelipeds slightly shorter than carapace; merus and propodus subequal, basis extending along ventral surface of ischium for almost one-third length of latter, carpus almost half length of merus. Merus and carpus densely tuberculated on all surfaces, tubercles of ventral surface smaller and scattered, two larger spinous tubercles on dorsal surface of merus, one about half-way along and the other overlying distal edge; propodus lacking tubercles, compressed and diminished distally, fingers bluntly toothed along inner edges; dactyl half length of propodus, lacking a basal tooth (in the female).

Measurements: Large male, length 165 mm. (Hale, 1927a); ovigerous female, length 136 mm., width 118 mm. (Rathbun, 1918).

Colour: Red in life, fingers and undersides of hand yellow (Hale, 1927a). A small orange-red spot on the outside of the chela near the articulation of the propodus and dactyl (Rathbun, 1918).

Depth: Shore to at least 450 fms. (Hale, 1927a).

Remarks: The holotype of *Leptomithrax australiensis* Miers, according to photographs (pl. 2) kindly forwarded by Dr. I. Gordon of the British Museum of Natural History, London, agrees extremely well with the holotype of *L. gaimardii* described above, differeing only in that the marginal spines of the carapace in the former are somewhat sharper. The Australian Museum syntypes of *Leptomithrax spinulosus* Haswell differ only from the types of *L. gaimardii* and *L. australiensis* in the greater prominence of the accessory spinules of the postorbital spine and basal antennal article. Also the lectotype and most of the paralectotypes of *L. spinulosus* lack the small tubercles associated with the accessory spinules of the postorbital spine in the types of the other two species. However, some of the other paralectotypes of *L. spinulosus* do possess these smaller tubercles. Such differences as have been outlined above are not considered sufficient to warrant separation into three species and *L. australiensis* Miers, 1876, and *L. spinulosus* Haswell, 1880, are therefore reduced to synonymy with *L. gaimardii* H. Milne Edwards, 1834.

Several additional characters of this species have been recorded in the literature. Rathbun (1918) noted that the ventral surface was especially setose in the females and young, but a transverse band at the articulations of the merus and ischium of the outer maxillipeds was always naked and smoothly rounded, and that the sternal segments in the male bore concavities but were not deeply guttered. These excavations are also found in several other species of *Leptomithrax*. Hale's figure (1927a: fig. 135) of a senile male shows the merus and carpus of the cheliped as smooth. This feature is in marked contrast to the situation found in several other species of *Leptomithrax* such as *L. australis* (Jacquinot, 1853) and *L. longipes* (Thomson, 1902), in which these segments of the cheliped are strongly tuberculate in the adult but smooth in the juveniles and females. Hale also noted that numerous large males of this species

were washed up on shore after heavy storms, the fingers of the cheliped in these old individuals being frequently crossed and utterly useless as pincers and, in addition, that the carapace was frequently covered by a dense framework of fine, macerated fibres of seaweed which had collected masses of silt.

Leptomithrax gaimardii is closely related to several other Australian species, namely *L. waitei* (Whitelegge, 1900), *L. globifer* Rathbun, 1918, and *L. sternocostulatus* (H. Milne Edwards, 1851) and a single New Zealand species, *L. richardsoni* Dell, 1960, all of which have accessory spinules or tubercles on the posterior edge of the postorbital spine. The less spinous carapace distinguishes *L. gaimardii* from *L. waitei* and the more numerous marginal branchial spines separate it from *L. sternocostulatus*. The absence of a spine on the anterolateral corner of the supraorbital eave distinguishes *L. gaimardii* from *L. richardsoni*, so that the closest relative is *L. globifer*, from which it differs in the stouter carapace and rostral spines and the presence of small spinules between the major marginal branchial spines.

Genus **Paramithrax** H. Milne Edwards, 1834

Paramithrax barbicornis (Latreille, 1825)

Text-figs. 7-14.

Pisa barbicornis Latreille, 1825: 141.

Paramithrax barbicornis, H. Milne Edwards, 1834: 324. Desmarest, 1858: 14. Not *Paramithrax barbicornis* Miers, 1876a: 219 = *Paramithrax ursus* (Herbst, 1788).

Lobophrys barbicornis, Filhol, 1886: 360.

Gonatorhynchus tumidus Haswell, 1880a: 437, pl. 25 figs. 4, 4a; 1880b: 145, 1882: 10. Miers, 1886: 25. Fulton and Grant, 1906b: 16. McCulloch, 1913: 335, fig. 46. Hale, 1927a: 130, fig. 129.

Gonatorhynchus barbicornis, Balss, 1929: 18, pl. 1 fig. 4.

Holotype: Female (dimensions not available), Muséum National d'Histoire Naturelle, Paris. A photograph of this specimen was published by Balss (1929: pl. 1 fig. 4), from which it may be seen that, apart from the absence of the second and third left and fourth right ambulatory legs, the propodus and dactyl of the fourth left and second right, and the dactyl of the remaining ambulatory legs except that of the third right, the specimen is in excellent condition. However, according to Dr. J. Forest (pers. comm. 1962) this specimen is no longer available in the collections of the Museum.

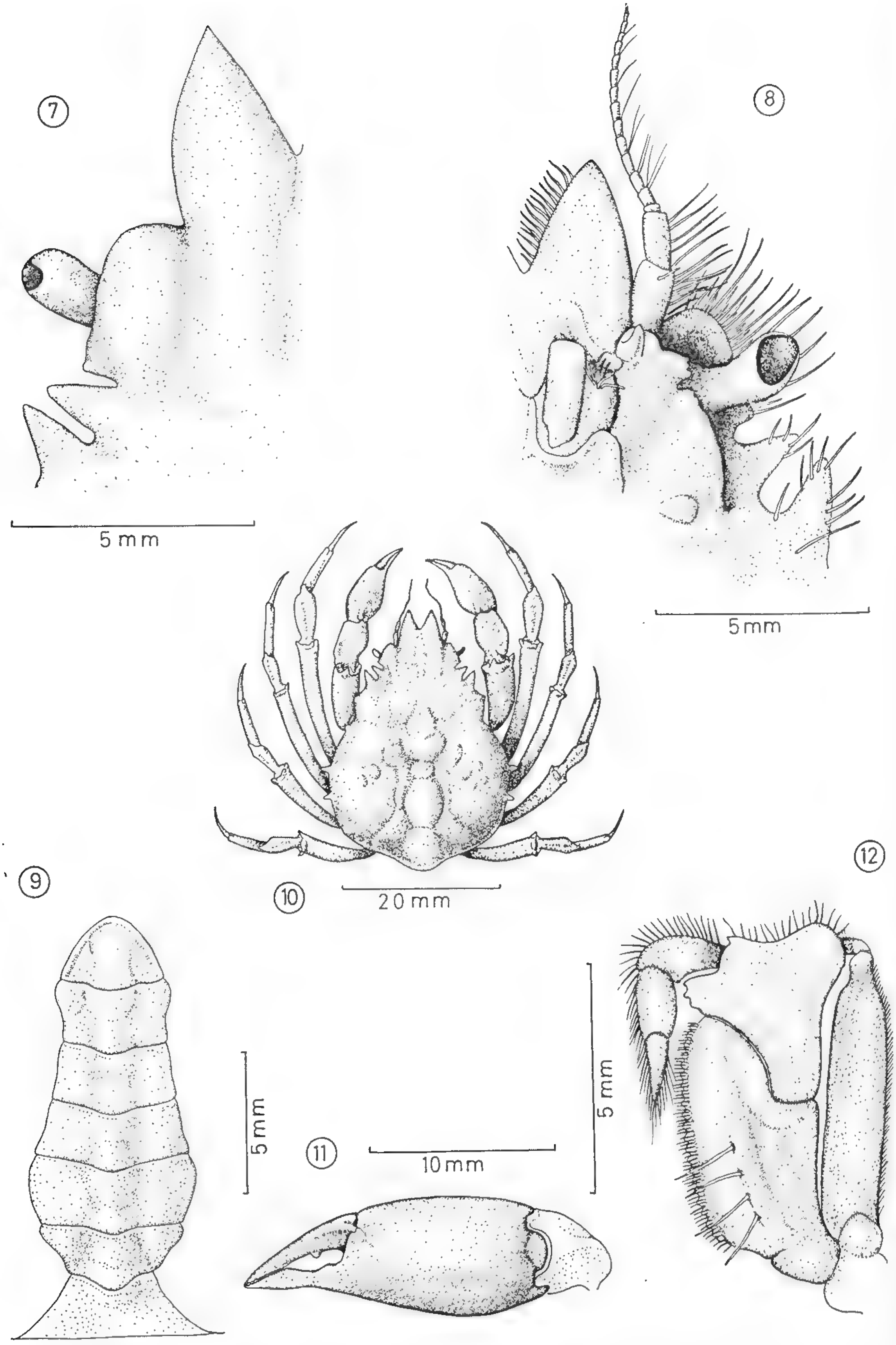
Type locality: Australia.

Types of Gonatorhynchus tumidus:—

Two syntypes, both dry male specimens (Aust. Mus. No. G.5107) mounted on glass with printed label "Type. G.5107. *Gonatorhynchus tumidus* Haswell. Loc. Port Jackson, New South Wales" and hand-written label "17. Port Jackson". A lectotype is here selected as follows:—

Lectotype: The lower of the two syntypes, referred to as G.5107a, length 30 mm., width 20.5 mm. The right cheliped is now missing and the left hand is detached, but the specimen is cleaned. According to Dr. Yaldwyn (pers. comm.) this is definitely the specimen on which Haswell's figure (Haswell, 1880a: pl. 25 fig. 4) and measurements were based.

Paralectotype: The upper of the two syntypes (G.5107b), an undamaged and uncleaned specimen.



Text figs. 7-12: *Paramithrax barbicornis* (Latreille), 30 mm. study male. 7. supraorbital detail, left side; 8. infraorbital detail, left side; 9. abdomen; 10. whole specimen, dorsal aspect; 11. left chela, outer aspect; 12. left third maxilliped.

Localities subsequently reported: Port Jackson, New South Wales, to Port Phillip, Victoria, south-western Australia (McCulloch, 1913); South Australia (Hale, 1927a).

Material examined: A single male (Aust. Mus. No. P.11721) from the collections of the Australian Museum, Sydney: three miles off Broken Bay, New South Wales, disgorged by rock cod caught with hand line and baited hook, coll. J. Phipps.

Diagnosis: Carapace narrowly pyriform, dorsal surface with scattered tubercles, margins weakly spinous. Rostral spines short, fused for basal third. Postorbital and intercalated spines short, subequal. Basal antennal article notched laterally close to anterolateral angle, anterolateral tooth flattened, short, outwardly directed, anteromedial tooth spinous, curved downwards and forwards. Merus of external maxillipeds expanded laterally. Carpus of cheliped with a strong lateral ridge, no dorsal ridge, dactyl with a small basal tooth on inner edge.

Description: Carapace narrowly pyriform in dorsal aspect (length about 1.4 times width), moderately swollen, setose. Rostrum of two short, stout, triangular, depressed spines (one-eighth length of carapace), fused for basal third, margins weakly convergent. Hepatic margin with a small tubercle midway along; branchial margin with two short spines situated close together at widest part of carapace and a small tubercle anteriorly. Dorsal surface of carapace smooth, lacking spines, a row of small, irregularly shaped tubercles extending along medial margin of branchial regions. Regions of carapace moderately well defined by shallow grooves.

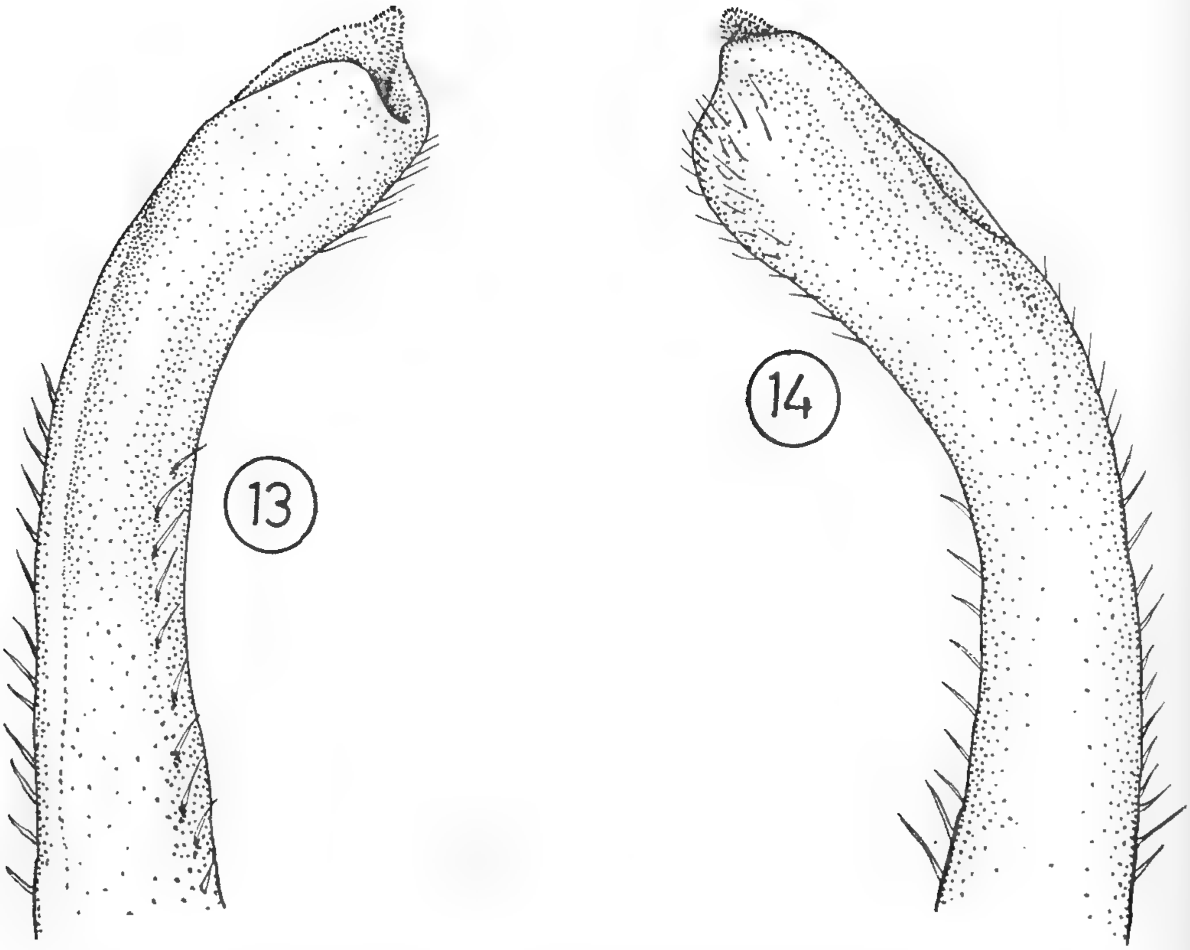
Orbit consisting above of supraorbital eave, intercalated spine and postorbital spine, the three separated by wide fissures; supraorbital eave broad, sharply angled anteriorly, a small tooth at posterolateral corner; intercalated spine short (one-third length of rostrum), subconical; postorbital spine remote from orbit, very slightly longer than intercalated spine, subconical. Orbit incompletely formed below by basal antennal article. Eyestalk short, slender, bulbous basally; cornea small, subterminal, slightly ventral.

Interantennular spine poorly developed, blunt.

Basal antennal article narrowly subrectangular, narrowing slightly anteriorly, lateral edge notched anteriorly, anterolateral angle extended laterally as a short, flattened, rounded, crenulate tooth; anteromedial angle curved downwards and forwards as a short, conical spine; flagellum long, extending for half its length beyond, and visible in dorsal view on each side of, rostrum.

Ischium of outer maxilliped longitudinally subrectangular, medial edge coarsely toothed, overlain but not concealed by a thick fringe of long hairs, medial half of distal edge produced distally as a long, narrow, rounded process; outer surface excavated medially as a wide, shallow groove, a few long hairs arising medial to groove. Merus subquadrate, very slightly wider, but somewhat shorter than, ischium, anterolateral corner produced laterally as a rounded process, distal edge notched, a small sharp tooth at lateral angle of notch, anterior part of lateral edge fringed by long hairs, outer surface weakly elevated as a rounded ridge extending along medial edge. Palp arising from notch of merus, stout, subcylindrical, tapering to a blunt point, segments subequal; lateral surface of all segments and medial surface of dactyl setose.

Chelipeds short, almost as long as carapace, subcylindrical to compressed, surfaces lacking spines or tubercles, naked; merus and propodus subequal, each about one-quarter total length of cheliped, carpus hardly as long as merus, dactyl slightly shorter than propodus. Merus weakly compressed, bluntly carinate dorsally; carpus subcylindrical, a blunt entire ridge extending obliquely across lateral surface, somewhat dorsal proximally; propodus strongly compressed, enlarged midway along, diminished



Text figs. 13, 14: *Paramithrax barbicornis* (Latreille), 30 mm. study male, Broken Bay, N.S.W.: left first pleopod tip. 13. abdominal aspect; 14. sternal aspect.

distally, upper surface blunt for entire length; fingers acute, moderately gaping basally, finely toothed along inner edges for distal half; dactyl cylindrical, a small inwardly projecting basal tooth on inner edge.

Ambulatory legs short, stout, cylindrical, covered by very long hairs, dactyl terminating in a sharp claw. First leg the longest (1.1 times carapace length), legs decreasing rapidly and uniformly to the last (0.7 times carapace length).

Abdomen of seven segments. Male abdomen widest at middle of third segment; first segment wide basally, narrow distally, second segment widening distally, fourth and following segments narrowing slightly to base of sixth segment which widens distally, seventh segment subtriangular; surface of all segments except first elevated in midline as a rounded longitudinal ridge bearing a small medial tubercle distally, a small tubercle laterally on each side of ridge in third segment.

Male first pleopod long, rather stout, bulbous basally, outwardly curved distally, aperture located terminally, opening medially as a short longitudinal groove; medial surface expanded distally as a stout process almost completely filling groove formed by curved lateral surface, and extending a short way beyond; lateral surface densely covered distally by short, fine setae; a row of slightly stouter and longer, simple setae along lateral surface for almost entire length, except distally; a row of similar setae scattered along medial surface to base of aperture.

Measurements: Study male, length 30 mm., width 21.5 mm., rostral length 4 mm., rostral width 5 mm., cheliped 27 mm., chelar length 15.5 mm., chelar height 6 mm., dactyl 7 mm., first ambulatory leg 34 mm.

Remarks: Comparative examination of the study specimen before me and of the photograph of the holotype of *Paramithrax barbicornis* (Latreille) given by Balss (1929) shows many similarities and no important differences. The two specimens agree in the pyriform shape of the carapace, the form of the short, double rostrum, in orbital detail, and in the number and arrangement of the marginal spines of the carapace. In the holotype the lateral ridge of the carpus of the cheliped is less pronounced and the chela is somewhat more slender than in the specimen before me. Since the holotype is a female and the study specimen a male, the latter difference may be attributed to sexual dimorphism. In addition, although both specimens have the dorsal surface of the carapace smooth with but a few low tubercles, in the holotype the regions are less well defined. In view of the foregoing remarks, I have no hesitation in assigning the study specimen to *Paramithrax barbicornis* (Latreille).

This study specimen differs from the holotype of *Gonatorhynchus tumidus* as described by Haswell in only three main features: Haswell (1880a: figs. 4, 4a) shows the hepatic margin with several small spinules, not present in this specimen; the basal antennal article is shown as hardly narrower anteriorly than posteriorly, presumably an error on Haswell's part; and the junction of the excavation and the distal toothed portion of the fixed finger of the chela is shown as somewhat sharper than in the specimen before me. None of these differences are sufficient to separate the study specimen specifically from the holotype of *G. tumidus*.

As noted above, *Paramithrax barbicornis* was designated as the type species of the genus *Paramithrax* H. Milne Edwards, 1834, by Desmarest (1858), and therefore must retain the generic name *Paramithrax*. Thus *Gonatorhynchus* Haswell, 1880, and *Lobophrys* Filhol, 1886, are reduced to synonymy with *Paramithrax*, as they are both based on the same type species. Comparison of *P. barbicornis* with those species at present included in *Paramithrax* (e.g., *P. peronii* H. Milne Edwards, *P. minor* Filhol, *P. baeckstroemi* Balss, etc.) indicates that the latter species are not congeneric with *P. barbicornis*. The status of the genus *Paramithrax* and the generic position of the above species will be considered in more detail elsewhere (see Griffin, 1963).

Comparison of *P. barbicornis* with the New Zealand and Australian *P. ursus* (Herbst, 1788) (= *P. latreillei* Miers, 1876) reveals at once why these two species were confused by early carcinologists. The general appearance of the two is indeed very similar, e.g., carapace pyriform, ambulatory legs short, carapace and legs covered by very long hairs, rostral spines short and other spines of the carapace restricted to the anterolateral margins. It is only closer examination of the spines, orbit, basal antennal article, third maxillipeds, male abdomen and male first pleopod which shows up differences of sufficient importance to separate the two at least specifically.

ACKNOWLEDGEMENTS

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I also wish to express my gratitude to Dr. J. Forest, of the Muséum National d'Histoire Naturelle, Paris, for supplying photographs of the holotype of *Leptomithrax gaimardii*; Dr. I. Gordon, of the British Museum of Natural History, London, for photographs of the holotype of *Leptomithrax australiensis*; Dr. John S. Garth, Allan Hancock Foundation, Los Angeles, and Dr. L. B. Holthius, Rijksmuseum van Natuurlijke Histoire, Leiden, for helpful advice; Mr. F. A. McNeill, Australian Museum, Sydney, for supplying the specimen of *Paramithrax barbicornis*, and Dr. J. C. Yaldwyn, of the Australian Museum, for information about the types of *L. spinulosus* and *G. tumidus* and for helpful discussion and careful criticism of the manuscript.

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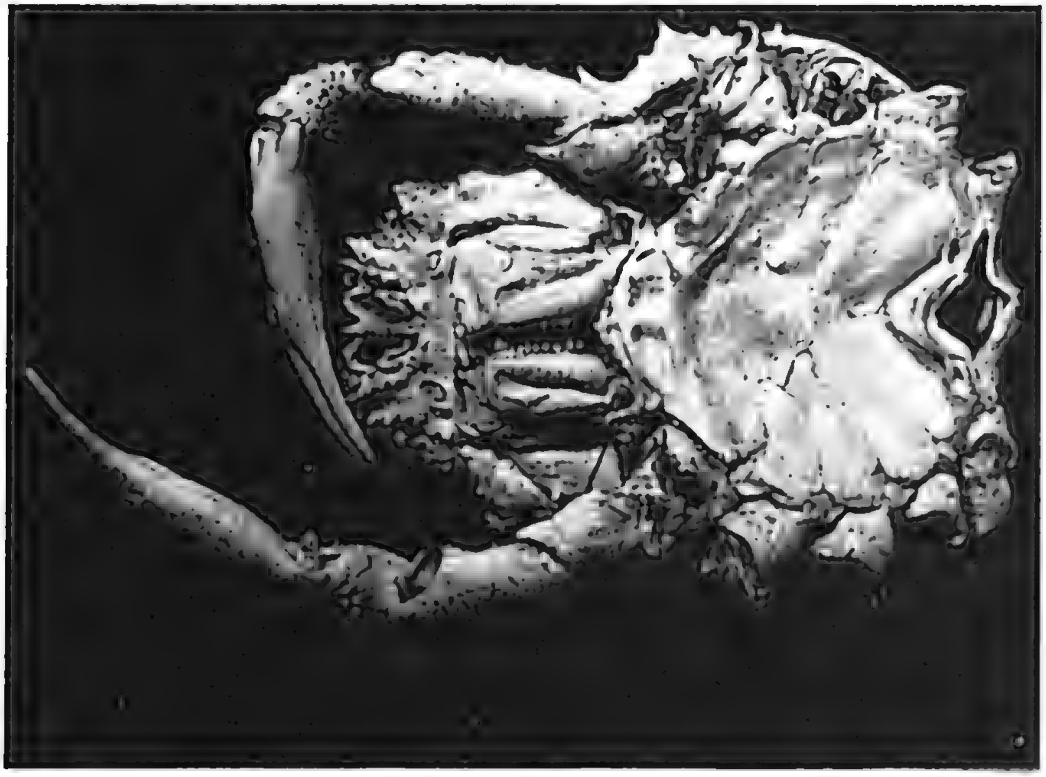
EXPLANATION OF PLATES

Plate 6. *Leptomithrax gaimardii* (H. Milne Edwards, 1834), holotype, 107 mm. female, Muséum National d'Histoire Naturelle, Paris, loc. New Zealand, coll. Quoy and Gaimard. (Photographs reproduced through kindness of M. J. Forest). Left: dorsal aspect; right: ventral aspect.

Plate 7. *Leptomithrax australiensis* Miers, 1876, holotype (=*L. gaimardii*), 76 mm. female, British Museum (Natural History), B.M. Reg. No. 1962. 7.19.1, loc. Tasmania (according to published description). (Photographs reproduced through kindness Dr. I. Gordon). Lower fig., dorsal aspect; upper fig., ventral aspect.



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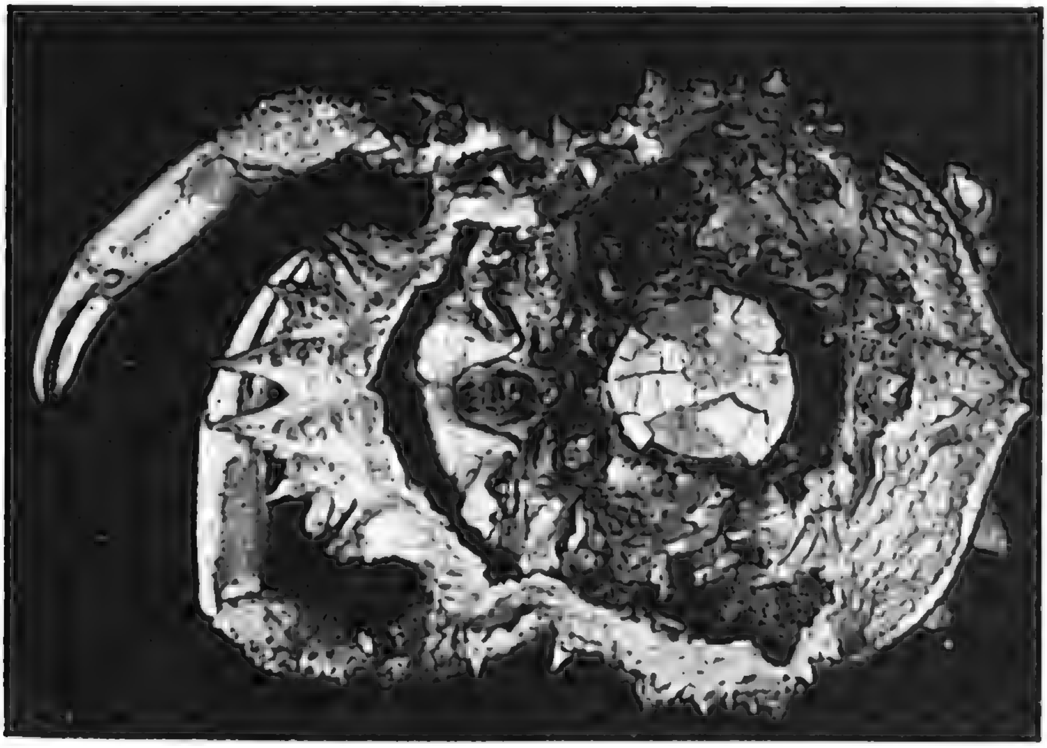

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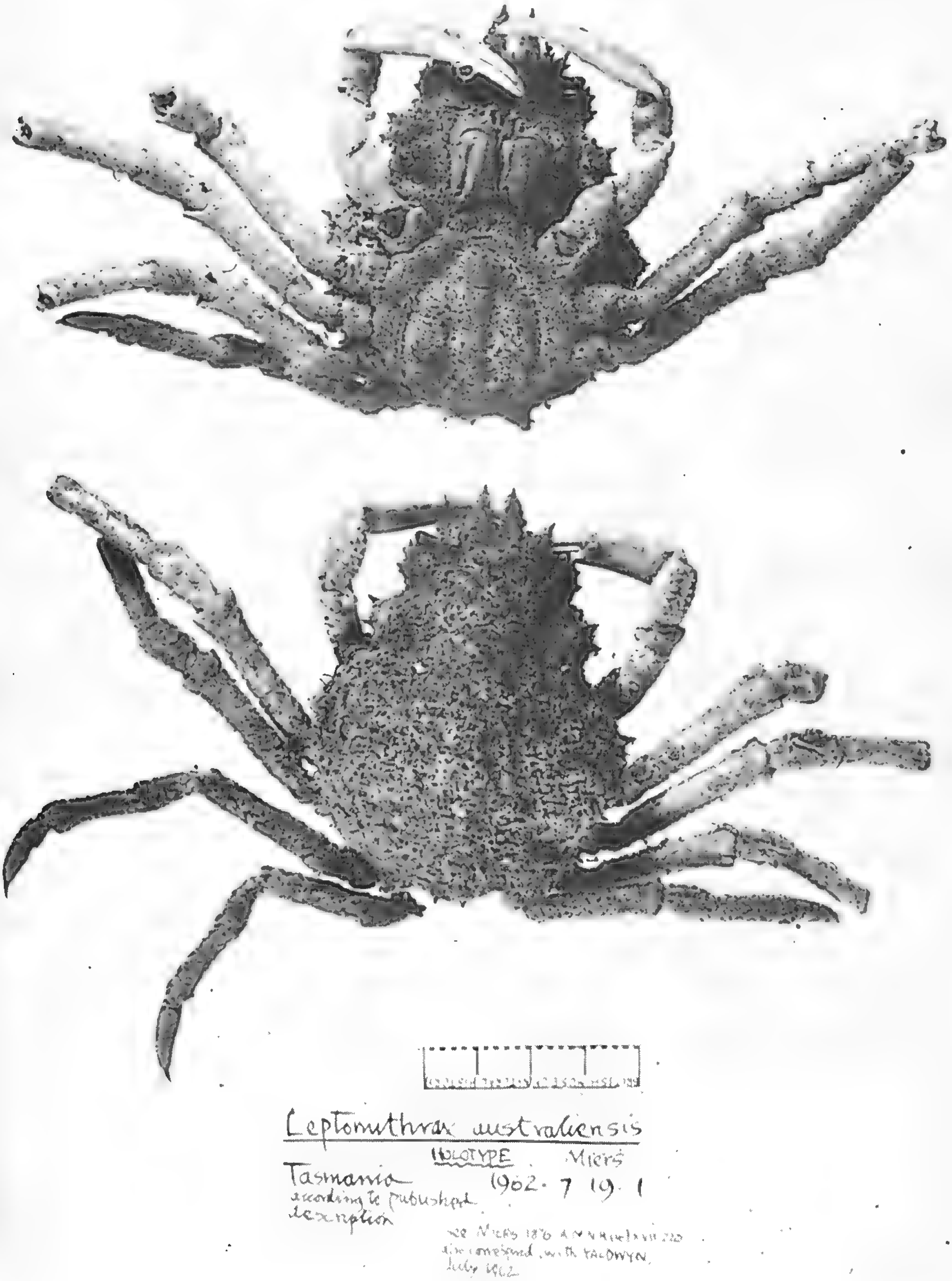

Leptomithrax australiensis
HOLOTYPE Miers
Tasmania
1902. 7 19. 1
according to published
description

FISHES FROM THE CORAL SEA AND THE SWAIN REEFS*

By Gilbert P. Whitley

Australian Museum

Plates 8-10 Figs. 1-15 Manuscript received 15-2-63

INTRODUCTION

The scattered islets and reefs in or near the Coral Sea to the east of Queensland are very remote and few zoologists have visited them. An account of the only zoological collection made at Elizabeth and Middleton Reefs appeared in the *Australian Zoologist* 8 (4), 1937: 199-273.

Over the last 15 years or so the Australian Museum has received several well-preserved collections of fishes from Queensland, the Coral Sea, New Caledonia, Lord Howe Island and other South Pacific localities. The fish-fauna of Lord Howe Island has been catalogued by Waite (1904, *Rec. Aust. Mus.* 5 (3): 187-230; 180 species listed), but many new records have appeared in the last few decades.

The Australian Museum's acquisitions from New Caledonia were listed by Whitley (1961, *Proc. Roy. Zool. Soc. N.S. Wales* 1958-59: 60-65) but a valuable collection of 456 fishes made by Dr. D. F. McMichael from remote islands in the Coral Sea when he was aboard H.M.A.S. *Gascoyne* in 1960 has not hitherto been reported upon, except for the description of one new species (Whitley, 1962, *N. Queensland Nat.* 30 (131): 3). This collection contains many Melanesian species and has been of value in studies on their distribution; several novel species or ones of special interest are described or figured in this paper in association with the 577 fishes obtained during the brief visit to Swain Reefs, at the south-eastern end of the Great Barrier Reef, Queensland, of the Australian Museum's 1962 Expedition, which is the main object of this report. Altogether 102 different species were collected, but only the more interesting sharks and fishes are dealt with below.

Most of them are conspecific with Queensland coral reef forms (especially with those already known from the Capricorn and Bunker Groups) and with New Caledonia and Lord Howe Island species and all of them may be expected to range over a wide area of Indo-Pacific seas when their distribution is better known. Only three of the Swain Reefs species appear to be new: a shark related to a Papuan one, a sea-horse also dredged in Moreton Bay, and an Apogonid with no known affiliations.

Two tunnies of possible commercial importance occurred in schools during our visit: the Frigate Mackerel, *Auxis thazard*, and the Mackerel Tuna, *Euthynnus wallisi*.

Some species of fishes (notably parrot and unicorn fishes) were seen but not collected—they are not listed here. Larval fishes and a few " difficult " species have not been identified.

* Including results of the Australian Museum 1962 Swain Reefs Expedition.

By hand-lining we obtained Red Emperor, *Diacope sebae*; Coral Cod, *Plectropomus maculatus*; Emperor-Sweetlips, *Lethrinus chrysostomus*, also *Variola louti* and *Epinephelus forsythi*, all good food-fishes.

Time did not permit investigation of the fascinating inter-relationships of fishes with invertebrates and other fishes. Parrot-fishes were, however, observed to upend themselves to be cleaned by *Labroides dimidiatus*. The association between a sea-urchin and the fish *Siphamia zaribae* and a shrimp (Whitley, 1959, *Proc. Roy. Zool. Soc. N.S. Wales* 1957-58: 15-17) already recorded from the Capricorn Group, was observed afresh. When the urchin was taken from the water some of the fishes sheltered in the collector's trouser-legs! Some *Lovamia* were practising buccal incubation. Fertile eggs were found in a female *Merogymnus jacksoniensis* suggesting that internal fertilization takes place, although it is not known if this would be followed by oral incubation as in its West Indian ally, *Opisthognathus* (see Böhlke and Chaplin, 1957, *Science* 125 (3243), Feb., 22: 353, fig. 1). *Dascyllus aruanus* was scarce although its usual host coral was present, and there were few *Amphiprion* with sea-anemones. Mimicry of a toadfish (*Canthigaster*) by a leatherjacket (*Paraluteres*) was noticed; several blennies (*Meiacanthus*) were nesting in empty gastropod shells and juveniles floated under sargasso weed. Other fishes were attacked by crustacean parasites.

Acknowledgments

For help with the loan of fishing nets, wire, winches and other collecting gear the expedition is grateful to the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, and to Dr. Donald Francois, of the State Fisheries Branch, Chief Secretary's Department of New South Wales. Mr. A. Mitchell, of Port Stephens, lent shark-lines.

The angling experience of Mr. Athel D'Ombrain, of our party, was of great value in the course of the expedition, and Mr. Robert Poulson's pilotage amongst the reefs as well as his hospitality at Heron Island were much appreciated. The Great Barrier Reef Committee's Marine Biological Station, Heron Island, kindly made facilities and specimens available.

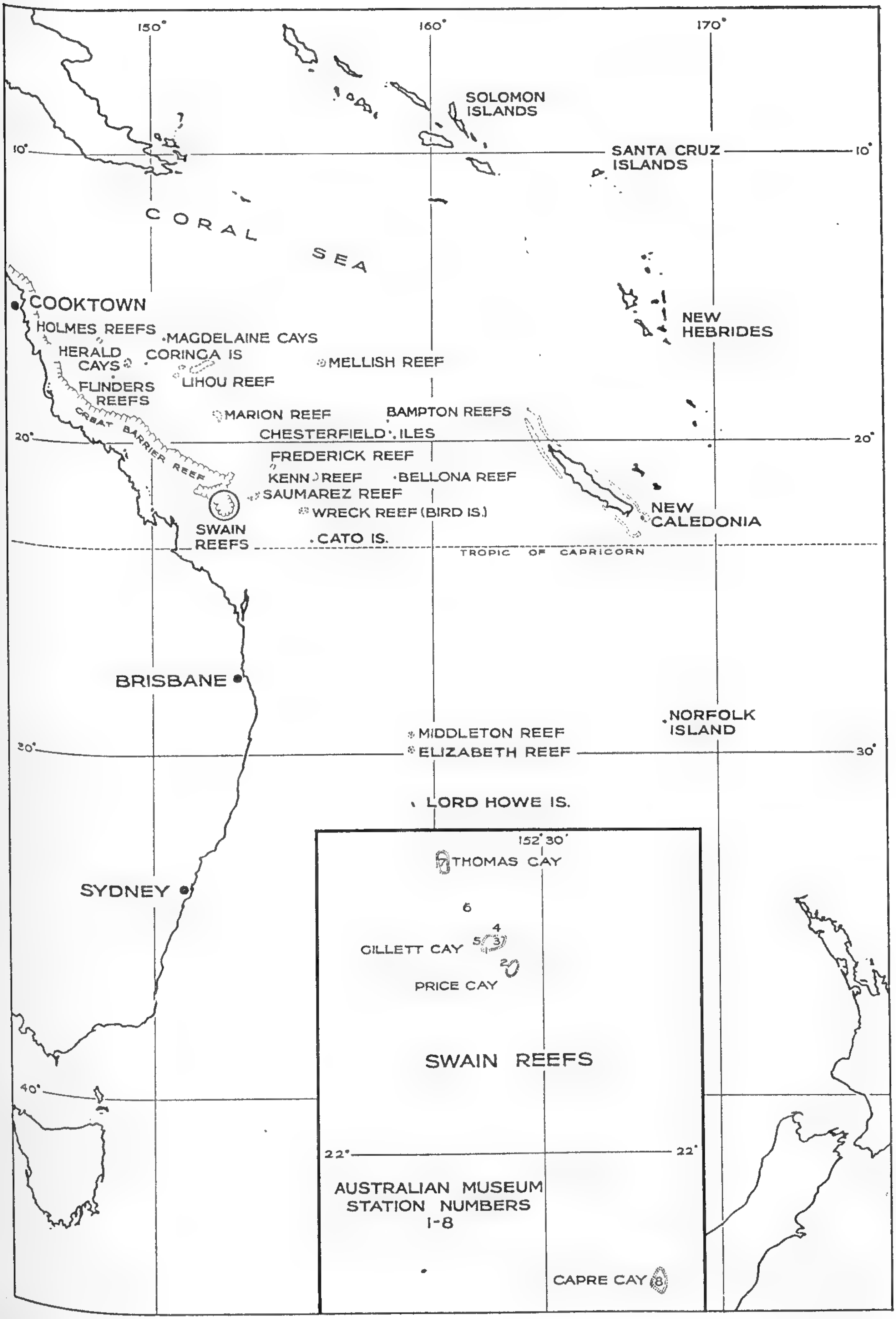
Excellent photographs from fresh specimens were taken by Mr. Anthony Healy, to whose skill I am indebted for several illustrations to this report and for kodachrome records of transient life-colours.

I am obliged to my former assistant, Miss L. Carter, for help in arranging this paper for the press and in preserving and cataloguing the specimens.

HISTORICAL NOTES ON SWAIN REEFS

Because of their isolation, distance from suitable ports, and the dangerous reefs in their waters, the Swain Reefs have received little attention from naturalists or fishermen until recent years. The earliest published reference to them seems to be Matthew Flinders' remarks (1814, *Voy. Terr. Austr.* 2: 101) that the easternmost parts of the barrier are probably connected with those further distant which Captain Swain of the *Eliza* fell in with in 1798. " If so, the Barrier Reefs will commence as far south-eastward as the latitude 22° 50′ and longitude about 152° 40′ and possibly still further . . . " " Mr. Swain did, indeed, get out at the latitude 22°; but it was by a long, and very tortuous channel."

MAP OF THE CORAL SEA



The reefs were visited over the years by trepang fishermen but were probably avoided as much as possible by whalers and traders in the nineteenth century. They are not mentioned in P. P. King (1826, Narrative of a Survey of the intertropical and western coasts of Australia, 2 vols.) who, however, gave Sailing Directions (l. c. 2: 259) for Lady Elliot's Island and (*ibid.*: 384 et seq.) for Elizabeth Reef, Kenn's Reef and other shoals and reefs in the Coral Sea.

J. B. Jukes (1847, Narrative of the Surveying Voyage of H.M.S. *Fly*, 1: 13) visited Swain Reefs aboard H.M.S. *Fly*, with the *Bramble* in company, in January, 1843. The *Bramble* investigated the inner reefs but the *Fly* worked outside them and up towards Bowen. Dirty weather was experienced for a while. Jukes landed on more than one reef and mentioned various corals and collected shells, holothurians, crustacea and echinoderms, including a dark purple comatula or sea-lily (*ibid.*: 16). The ship's anchor brought up a block of coral rock which the naturalist broke open to obtain an amazing variety of living creatures: " this block was not above a foot in diameter, and was a perfect museum in itself . . . What an inconceivable amount of animal life must be here scattered over the bottom of the sea, to say nothing of that moving through its waters, and this through spaces of hundreds of miles."

Many " flat circular disks " were brought up on the lead which Jukes thought were the " marginopora of De Blainville ", but Professor Forbes informed him that they were disks of acetabularia (see also page 325).

Jukes made no mention of any fishes amongst the Swain Reefs.

On page 320 et seq. of his book be briefly described the reefs and soundings and mentions they were named because first traversed by Mr. Swain, in the brig *Eliza*, 1798.

A less formal account of Jukes' life and travels appeared in " Letters and extracts from the addresses and occasional writings of J. Beete Jukes . . . " (London: Chapman and Hall), 1871. On page 175 the Swain Reefs are mentioned but no natural history is related. Jukes was relieved by the passing of the storm there: "*Feb.* 2 [1843] What a relief! A lovely morning, smooth, and clear skies. Up, top-masts, top-gallants and royals! Heave away on the Capstan; up with the anchor, and away we go again."

H.M.S. *Herald* may have surveyed in about the 1850's in the vicinity of Swain Reefs. I have not traced any published consecutive account of her voyages, which were extensive around Australia. (Compare, however, Whitley, 1937, *Austr. Zool.* 8: 207-208, also Ingleton, 1944, *J. Roy. Hist. Soc. Austr.* 30 (4): 268, and his book " Charting a Continent ", 1944, passim., as well as Whittell, 1954, *Lit. Austr. Birds*: 465 and 608 and Denham, 1873, *Table of Positions in the Pacific Ocean in H.M.S. Herald*, 1852-1860.)

In the 1880's, an old sandalwood trader and South Seas skipper, A. E. Sykes, wrote some articles under the pseudonym " S.E.A." in a Rockhampton (Queensland) newspaper (probably the " Bulletin " of October 25, 1913, and some undated cuttings seen in the Mitchell Library) but there is no particular natural history in such of his accounts as are available; he had been to the Swains and to Wreck Reef and other places in the Coral Sea in 1850 and the late 1860's.

Saville-Kent noted fishes from Lady Elliott Island in his classic book on The Great Barrier Reef of Australia, 1893.

Norman Caldwell (1952, Outdoors and Fishing, June, 1952: 107) referred to numerous dangerous eels infesting the waters of Swain Reefs.

Mr. Keith Gillett visited Swain Reefs in October, 1960, and favoured me with a copy of his manuscript journal. At Poulson Cay on October 31, 1960, his small dinghy was attacked by a large shark which struck at the propeller of the outboard motor; he thought it may have been attracted by the noise and vibration. A preliminary illustrated account of Gillett's visit appeared in the magazine " People ", November 8, 1961: 27-30.

The first zoological data to emerge from the Reefs and some excellent photographs were published in the second edition of Gillett and McNeill's " The Great Barrier Reef and Adjacent Isles ", published in September, 1962.

As regards ichthyology, the first fishes from Swain Reefs came to my attention from the more venturesome fishermen who went there from Gladstone or Rockhampton in the late 1950's or early 1960's; some of their fishes were forwarded to the Australian Museum through the good offices of the harbour-masters at those ports or through the Department of Harbours and Marine, Brisbane. Mr. A. J. Meagher, in particular, supplied not only specimens but kodachrome transparencies of some of the commercial fishes which, as might have been expected, proved to belong to the same species as those of much of the Queensland coastline, even though the fishermen bestowed local vernacular names on them.

Mr. A. J. Meagher's vernaculars for fishes of Swain Reefs—identified from kodachromes:—

Red Emperor, *Diacope sebae.*
Tomato Cod, *Aethaloperca rogaa.*
33 lb Turrum, *Turrum emburyi.*
Crescent Trout, *Variola louti.*
Coronation Trout, *Plectropomus maculatus.*
Coral Trout, *Plectropomus maculatus.*
600 lb. Grouper, 8 feet, *Epinephelus vel Promicrops* sp.
40 lb. Mackerel, *Cybium commerson.*
" Blue Cod ", *Epinephelus* sp. Pale blue with inky spots, small and fewer large spots.
Yellow Sweetlips, 15 lb., *Lethrinus perselectus.*
Sweetlip, *Lethrinus chrysostomus.*
Plum-pudding Cod, *Chromileptes altivelis.*
Chinaman, *Symphorus nematophorus.*
Trout, *Plectropomus maculatus*—variety with black saddles on white ground.
Unicorn fish, *Cyphomycter* sp. Silver with blue spots and lines. Lips, gill-openings and bar from eye to snout vivid blue.

Through these friends I was able to identify a number of species and obtain for the Australian Museum (regd. no. IB. 5205-5217, 5412-14, 5736), such species as *Lethrinus chrysostomus*, *Lutjanus* sp., *Grammatorycnus bicarinatus*, *Moolgarda compressa*, and other commercial kinds, besides *Variola louti*, *Plectropomus maculatus*, *Lethrinella miniata*, *Anyperodon leucogrammicus*, *Abalistes stellaris*, *Cheilinus radiatus* and the sucker-fish. *Echeneis neucrates.*

It was obviously a rewarding area to the line-fishermen who worked in fairly deep water, but no data were forthcoming about the shoreline and coral-reef fishes of the cays and reefs, many of which were unexplored. Some light on these was thrown by the Australian Museum 1962 Swain Reefs Expedition, of which I was a member, since we collected 577 fishes referable to 102 species in the short period spent in the field (Austr. Mus. regd. nos. IB. 6006-6257, 6320 and 6351).

Considering the short time available for collecting, this haul compares favourably with those of other Museum trips to North-West Islet (44 species), Low Isles (96 species), Michaelmas Cay (72) and the Coral Sea (84).

ALPHABETICAL LIST OF THE SHARKS AND FISHES COLLECTED AT SWAIN REEFS BY THE AUSTRALIAN MUSEUM EXPEDITION IN OCTOBER, 1962

Abcichthys praepositus.
Acanthochromis maculosus.
Amblygobius phalaena.
Amphiprion clarkii.
Amphiprion verweyi.
Anampses pterophthalmus.
Apogonichthys coggeri, sp. nov.
Aspiscis savayensis.
Atherina sp. juv.
Atrosalarias fuscus
Auxis thazard

Bathygobius fuscus
Barbupeneus signatus
Belonepterygion fasciolatum
Blennodesmus scapularis

Callyodon toshi
Canthigaster valentyni
Caracanthus maculatus
Chaetodon rainfordi
Chaetodon setifer
Cheilinus chlorurus
Congrogadus subducens
Crenalticus meleagris
Cypsilurus melanocercus

Danichthys cribrosus
Dascyllus aruanus
Dinematichthys mizolepis

Ecsenius mandibularis
Eviota viridis

Farhians marginatus
Foa fo
Fowleria aurita
Fusigobius neophytus

Galeocerdo cuvier
Galeolamna bogimba
Galeolamna coongoola, sp. nov.
Galeolamna stevensi
Glyphisodon coelestinus
Gobiodon verticalis
Graviceps angelus
Guntheria trimaculata

Halichoeres hoevenii
Halophryne diemensis
Hemicoris pallida
Hemiscyllium ocellatum
Hippocampus zebra, sp. nov.

Istiblennius edentulus
Istigobius stephensoni

Labroides dimidiatus
Lepadichthys frenatus
Leptochromis tapeinosoma
Lethrinus chrysostomus
Lovamia cookii
Lutjanus chrysotaenia
Lycodontis cribroris

Meiacanthus grammistes
Merogymnus jacksoniensis
Microcanthus joyceae

Nectamia fusca
Negoscartes irroratus
Newtonscottia houlti
Norfolkia squamiceps
Norfolkia thomasi, sp. nov.

Oxymonacanthus longirostris

Paradentex bitorquatus
Paragobiodon echinocephalus
Paraluteres prionurus
Parapercis cylindrica
Pardachirus pavoninus
Parupeneus luteus
Pervagor (Acreichthys) tomentosus
Platyglossus notopsis
Plesiops nigricans
Priolepis necopinus
Pseudolabrus guntheri
Pseudopomacentrus flavicauda
Pseudopomacentrus sufflavus
Pseudopomacentrus wardi

Salarias fasciatus
Saurida gracilis
Scolecenchelys iredalei
Scorpaenodes guamensis
Scorpaenopsis diabolus
Sebastapistes bynoensis
Siphamia zaribae
Solenichthys leptosomus
Squamicreedia obtusa
Stegostoma tigrinum
Stethojulis renardi
Stethojulis strigiventer
Stolephorus delicatulus
Strongylura incisa
Suggrundus sp.
Synchiropus microps
Synclidopus normani

Tathicarpus subrotundatus
Tetrachaetodon plebeius
Teuthis sp.
Thalassoma lunare
Triaenodon apicalis
Turrum emburyi

Vauclusella atrogularis

A few doubtful species and larval material have been omitted. Other species were seen but not collected.

ALPHABETICAL LIST OF SHARKS AND FISHES COLLECTED BY Dr. D. F. McMICHAEL IN THE CORAL SEA, 1960

These totalled 456 specimens referable to 84 species, listed alphabetically below:—

C = Coringa Islet
F = Frederick Reef
He = Herald Cay
Ho = Holmes Reef
K = Kenn Reef
L = Lihou Reef
M = 12 miles E. of Magdalene Cay
S = Saumarez Reef
W = Wreck Reef (Bird Is.).

Acanthochromis polyacanthus. C, L.
Amblyglyphidodon curacoa. L.

Bothus mancus. W.

Caesio diagramma. F, L.
Callyodon lunula. K.
Callyodon sordidus. K.
Caranx sp. W.
Centropyge bispinosus. F, K, L.
Centropyge flavissimus. F.
Cephalopholis argus.
Cephalopholis urodelus. F.
Chaetodon dixsoni. F.
Chaetodon flavirostris. F.
Chaetodon lineolatus. F.
Chaetodon lunula.
Chaetodon melannotus. F.
Chaetodon pelewensis germanus. F, K.
Chaetodon setifer. K.
Chaetodon speculum. K.
Chaetodon trifasciatus. K.
Chaetodon unimaculatus. K, S.
Cheilinus oxycephalus. F.

Cheilinus trilobatus. K.
Chiloscyllium punctatum. S.
Chromis atripes. K.
Chromis dimidiatus. F, K, L.
Chromis dimidiatus var. F, K. L.
Chromis fragoris, sp. n. L.
Chromis kennensis, sp. n. K.
Chromis lepidolepis. K.
Ctenochaetus striatus. K.

Dactylanthias macmichaeli. L.
Dinematichthys iluocoetoides. K.

Epinephelus marginalis. F.
Exocoetus volitans vagabundus. M.

Forcipiger longirostris. F, K, L.

Galeolamna sp. F.
Glyphisodon septemfasciatus. He.
Gnathodentex aureolineatus. F, K.

Hemibalistes chrysopterus. F, K, S.
Hemitaurichthys zoster. F.
Holocenthrus diadema. F, K, S, W.
Holocenthrus laevis. F.
Holocenthrus sammara. F, K, S.

Iredaleichthys glaucus. W.

Kyphosus vaigiensis. He.

Lepicephalochromis westalli, sp. n. K, L.
Lovamia properupta, sp. n. F.

Macolor niger.
Megaprotodon strigangulus. S.
Mirolabrichthys tuka pascalus. F, L.
Monotaxis affinis. F.
Mulloidichthys auriflamma. F, K.
Myripristis murdjan. K.
Myripristis pralinius. F, K, S.

Naso hexacanthus. K.
Naso lituratus. F.
Naso unicornis. F, K.
Negostegastes lacrymatus. C, F, K.

Oedalechilus cirrhostomus. He.
Ostracion sp. juv. F.
Ostracion sebae. F.
Ostracion tuberculatus. S.

Pellochromis reticulatus. F, K.
Pervagor melanocephalus. K.
Pristiapogon diversus. K.
Pristiapogon snyderi. F.
Pseudochromis mccullochi. C, W.
Pseudogramma polyacanthus. W.
Pseudopomacentrus gascoynei, sp. n. F, K, W.
Pseudopomacentrus imitator, sp. n. L.
Pseudopomacentrus navalis, sp. n. K.
Pseudopomacentrus wardi. F, K, L.
Pterocaesio tile. F, K.

Salarias (Alticops) periophthalmus. K.
Scorpaenodes guamensis. K.
Sebastapistes bynoensis.
Siderea picta. W.
Sufflamen sp. F.

Tetrachaetodon plebeius. F, L.
Teuthis dussumieri. K.
Teuthis lineatus. K.
Teuthis nigricans. F, K.
Teuthis nigroris. F.
Teuthis triostegus. Ho.

Variola louti. F.

NEW SPECIES, RECORDS AND FIELD NOTES

Family **Galeidae**

Genus **Galeolamna** Owen, 1853

Galeolamna coongoola, sp. nov.

Fig. 1

A Whaler Shark with broadly rounded snout, dental formula $\frac{14.14}{14.1.14}$, cusps of upper teeth serrate, no interdorsal ridge, fairly large second dorsal and anal fins, mostly uniform grey in colour without white or black fin-tips.

Biometrics as in Table I.

Five small and eight larger pores in row external to corners of mouth. Last two gill-openings over pectoral base. Teeth of upper jaw slightly notched on inner edge, strongly notched on outer edge, coarsely serrate except towards tips. Teeth of lower jaw slenderer with rounded shoulders and only slightly serrated.

Predorsal profile sloping evenly, convex but not gibbous. No interdorsal ridge. L. lat. system inconspicuous. Denticles of skin crossed by 5 or 6 keels. No umbilical scar. Form elongate-cylindrical, depth 4.7 in standard length. Stomach contained fish bait (*Lethrinus chrysostomus*).

Colour, uniform grey above, greyish-white below. Fin-tips not coloured white or black, but the inferior surfaces of the lobes of the paired fins are dark smoky grey and the lobe of the anal is grey. An indistinct bar along the side as in most whalers.

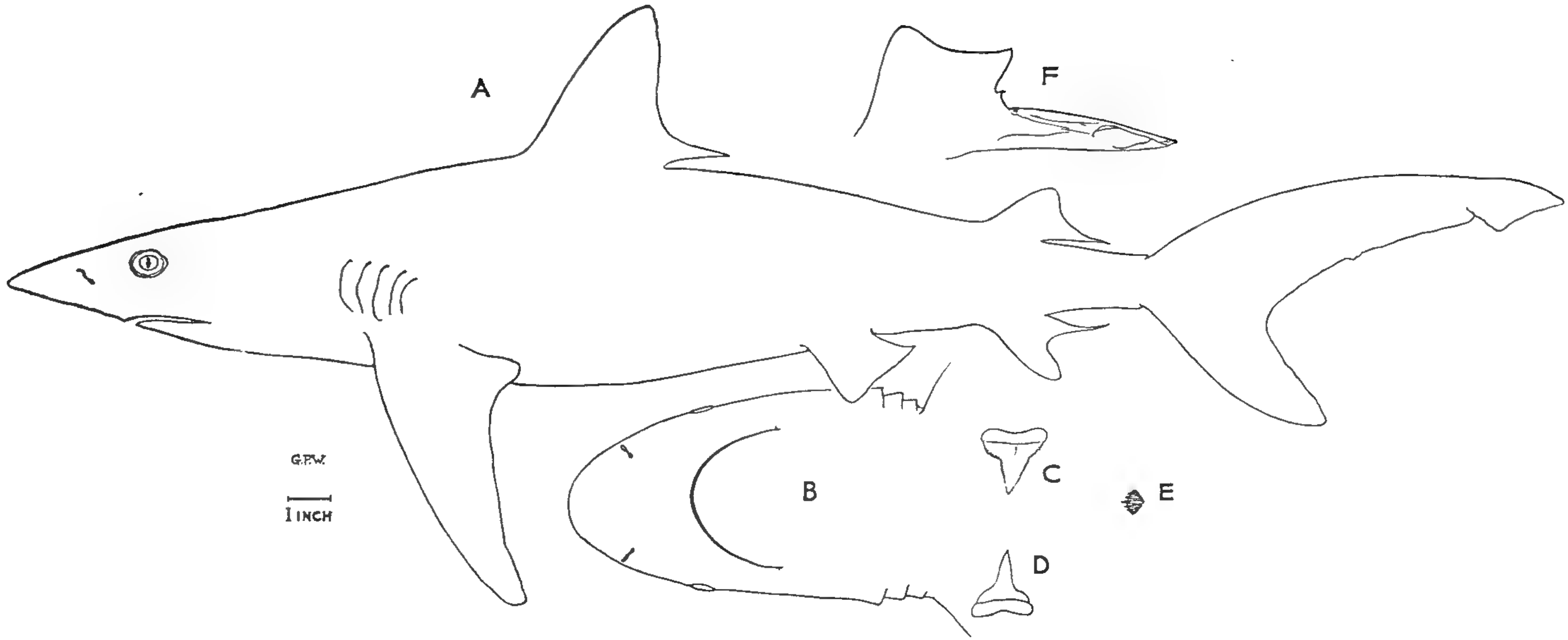


Figure 1.—Swain Reefs Whaler Shark, *Galeolamna coongoola*, sp. nov. A. Lateral view of female holotype. B. Ventral surface of head of same. C. Tooth from upper jaw of same. D. Tooth from lower jaw of same. E. Denticle from shoulder region of holotype. F. Ventral fin and clasper of male allotype, showing projecting spur between them.

Described and figured from the holotype, a quiescent or mimature female, 37 inches (940 mm.) in length overall; weight 10 lb. Australian Museum regd. no. IB. 6006.

Loc.—Gillett Cay, Swain Reefs, Queensland; 14.x.1962. Australian Museum 1962 Swain Reefs Expedition.

The male of this new species is similar to the holotype but has the following characters:—

Nostrils without conspicuous, pointed lobes. Labial folds moderately small. Eight pores external to labial folds. Dental formula $\frac{14.1.14}{14.1.13}$. Teeth rather broad, those of upper jaw notched both sides and coarsely serrated, those of lower jaw slender and lightly serrate.

Predorsal profile evenly sloping, not gibbous. No interdorsal ridge, merely a slight median rise along back. Biometrics as in Table I. Depth 4.6 in standard length. Denticles crossed by 5 or 6 keels.

Origins and ends of bases of anal and second dorsal fins about opposite or anal a trifle posterior. Pectoral origin under fourth gill-slit. Lower caudal lobe acutely rounded.

The stomach contained one large, digested octopus. Testes well developed, stretching almost length of coelome. A pointed, cartilaginous spur between ventral fin and clasper.

Colour: Pale greyish-brown, the first dorsal fin particularly pale. Other fins smoky grey. No conspicuous dark or light tips to fins. Eye with black pupil and silver iris.

Described from the male allotype, a specimen 4 ft. 9 in. long and 41 lb. in weight hooked off Capre Cay, Swain Reefs, 22.x.1962 by Mr. Raymond Marshall, during the Australian Museum 1962 Swain Reefs Expedition. Australian Museum regd. no. IB.6009 (teeth, denticles, ventral fin and clasper preserved).

The new species is like my Papuan *G. tufiensis* [Whitley, 1949, *Proc. Roy. Soc. N.S. Wales* 1947-48: 24 and 1951, Rec. Aust. Mus. 22 (4): 389, fig. 1] but that species has fewer teeth (about 22 to 27 across each jaw instead of 28 to 29), the upper ones being more deflected, and it has a smaller second dorsal fin.

Galeolamna (Ogilamia) stevensi (Ogilby)

Fig. 2 a-g

Carcharias stevensi Ogilby, 1911, *Ann. Qld. Mus.* 10: 38.
Bustard Bay and North-West Islet, Queensland.

Carcharhinus stevensi Ogilby, 1916, *Mem. Qld. Mus.* 5: 80 and 94. *Id.* McCulloch, 1919, *Austr. Zool.* 1 (7): 220, and of Australian lists. *Id.* Coppleson, 1933, *Med. J. Austr.*: 458.

Galeolamnoides stevensi Whitley, 1934, *Mem. Qld. Mus.* 10: 191.

Galeolamna (Ogilamia) stevensi Whitley, 1940, *Fish. Austr.* 1: 103 and 104 (not fig. 99) and 1943, *Proc. Linn. Soc. N.S. Wales* 58: 120 and 122, fig. 4.

Few examples of this species have been described, so details of two females from Gillett Cay and Capre Cay are appended. The diagnostic features are the presence of an interdorsal ridge, a tan or grey coloration, labial folds rather long and 13 or 14 teeth each side of the symphysial 1 or 2 in each jaw. Biometrics are given in Table I.

(*a*) *description of Gillett Cay example*

Profile convex, not very gibbous. Snout bluntly rounded. Twelve rows of pores external to labial folds. Nostril with acute lobe. Dental formula $\frac{14.1 \text{ or } 2.15}{14.2.14}$. Teeth very finely serrate on base and cusp in upper jaw. Serrae almost obsolete on lower jaw teeth. Lateral line inconspicuous. Denticles with six or seven carinae.

Dorsal origin over hinder part of pectoral base. Ends and origins of second dorsal and anal fins opposite (see figure 2, *a*). The left pectoral fin had scarcely-healed bite marks from another shark. Tip of upper caudal lobe showing very shallow notch between the lower flanges (see figure 2, *a*); the end of the lower caudal lobe is acutely pointed.

Colour in life tan above, light below, turning to grey after death, this drab, upper colour passing below level of eye. No dusky or white tips to any fins.

Stomach walls not well defined. Stomach contained brown fluid. No eggs or embryos.

Described from a female, 6 ft. 7 in. in total length; weight, 110 lb. Australian Museum regd no. IB.6008.

Loc.—Gillett Cay, Swain Reefs, Queensland; October 17, 1962. Australian Museum 1962 Swain Reefs Expedition.

(*b*) *notes on Capre Cay specimen*

Similar to (*a*), but nostril without conspicuous pointed lobe. Dental formula probably 14.1.14 in both jaws but side of upper jaw damaged by hook. Teeth strongly serrated in upper jaw; those of lower jaw with few small serrae. Last two gill-slits over pectoral base. First dorsal origin just behind level of end of pectoral lobe. Anal origin and end of its base a trifle forward of levels of those of second dorsal fin. For biometrics, see Table I.

A short interdorsal ridge. Denticles with 6 or 7 keels. No umbilical scar.

The stomach contained digested carangid remains and half a frigate mackerel (*Auxis thazard*). Gonads quite immature.

Described from a young female, 960 mm. long and 10 lb. in weight. Australian Museum regd. no. IB.6010.

Loc.—Capre Cay, Swain Reefs, Queensland; October 23, 1962. Australian Museum 1962 Swain Reefs Expedition.

Galeolamna (Bogimba) bogimba Whitley

Fig. 2 h-j

Galeolamna (Bogïmba) bogimba Whitley, 1943, *Proc. Linn. Soc. N.S. Wales* 68: 123, fig. 5. Bogimbah, Fraser Island, Queensland. Holotype in Australian Museum.

Eulamia bogimba Stead, 1963, *Sharks and Rays:* 86 and 200.

The second known example of this species was obtained. A large male, 8 ft. 4 in. long (2,500 mm.) and 295 lb. in weight, it was caught by Mr. Athel D'Ombrain at Gillett Cay on October 15, 1962, early in the afternoon on fish bait. Because of its large size and lack of time the full biometrics were not recorded, but some measurements appear in Table I. It is slightly smaller than the holotype of *bogimba*.

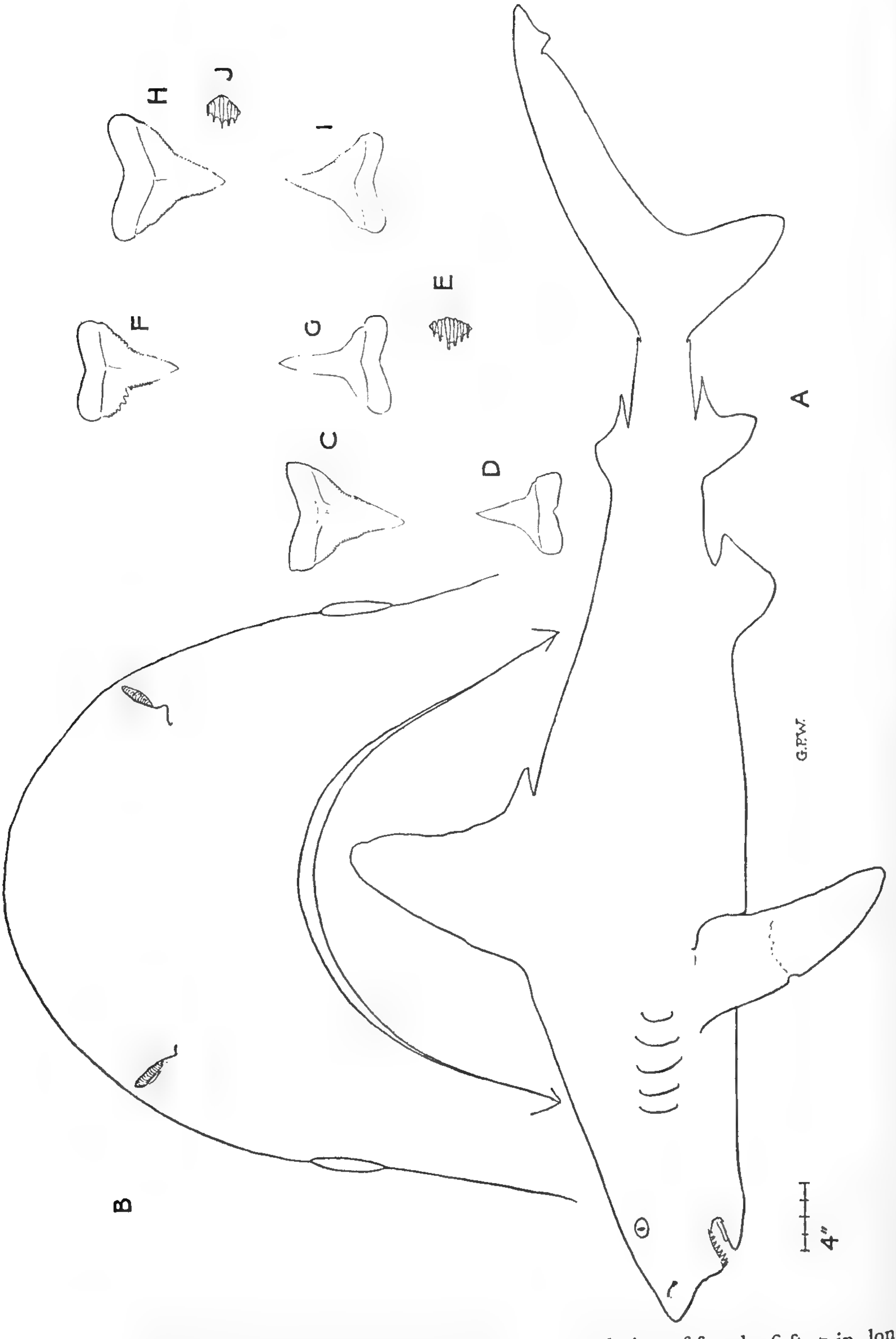


Figure 2.—Tan Whaler, *Galeolamna stevensi* (Ogilby). A. Lateral view of female, 6 ft. 7 in. long, from Gillett Cay. B. Ventral surface of head of same. C. Tooth from upper jaw. D. Tooth from lower jaw. E. Denticle from shoulder-region of same specimen. F. Tooth from upper jaw of Capre Cay female. G. Tooth from lower jaw of same. H. Tooth from upper jaw of large male *Galeolamna bogimba* Whitley. I. Tooth from lower jaw of same. J. Denticle for *G. bogimba*.

Snout bluntly rounded, almost semicircular. There was a pronounced bulge at the symphysis of the lower jaw. Last two gill-slits over pectoral. Dental formula $\frac{13.1.13}{12.1.12}$. Teeth serrated on base and cusp.

First dorsal fin situated behind level of pectoral base. Most of fin-lobes blunt, the second dorsal lobe short and stunted and the anal appeared as if worn down.

Denticles crossed by 5 or 6 keels. No interdorsal ridge.

Colour mostly uniform grey with no conspicuously marked fin-tips. Whitish below.

Stomach everted, empty; it had taken a fish bait (*Lethrinus chrysostomus*).

Described and illustrated from a mature male specimen, 8 ft. 4 in. long and 295 lb. in weight. Australian Museum regd. no. IB.6007. The complete specimen was not preserved, only denticles, jaws and teeth.

Loc.—Anchorage at Gillett Cay, Swain Reefs, Queensland. Australian Museum 1962 Swain Reefs Expedition, October 15, 1962, a clear sunny warm day. As in the case of the holotype, it was accompanied by three *Echeneis neucrates* and five *Gnathanodon speciosus*.

Galeolamna bogimba may now be recorded from New South Wales for the first time, since the third known specimen of the species was hooked in Sugarloaf Bay, Middle Harbour, Sydney, on January 29, 1963, by Mr. E. Campbell (Aust. Mus. regd. no. IB.6352). Biometrics are included in Table I. The specimen was the first female to be recorded and had the following characters:—

Preoral length 2.1 in width of mouth. Snout broadly rounded. Interorbital convex. Eyes small. A small symphysial tooth in each jaw. Teeth roundly notched in lower jaw, slightly serrated on base; cusp strongly serrated to tip. Teeth of upper jaw broadly triangular, broader than long, slightly deflected, slightly notched, rather strongly serrated on base and cusp, some of the serrae tridentate. Dental formula $\frac{13.1.13}{12.1.12}$.

Profile rounded, hunched but not gibbous. Body robust. No interdorsal ridge. Dermal denticles of shoulder region crossed by five or (more usually) six carinae.

Dark brownish grey after death. No dark or light tips to fins.

Stomach contained some blood (not human) and miscellaneous fish hooks, digested fish remains and a piece of iron, according to donor, but it disgorged some food which could not be identified during a dark and wet night when it was hooked.

Ovaries quiescent. Uteri flaccid. Had probably pupped. No bite marks on pectoral fins.

G. bogimba is apparently not the adult of *spenceri* as the characters separating them are probably more than can be accounted for by growth.

Key:—

A. Denticles tricarinate. Preoral length 1.2 to 1.5 in width of mouth. Pectoral short, 1.3 in head. Eye 4 or more in the preoral length. Depth of gill-slits about twice eye-diameter .... *spenceri*.

AA. Denticles with five or six carinae. Preoral length 1.8 to 2.1 in width of mouth. Pectoral longer, 1.2 in head. Eye more than 7 in preoral length. Depth of gill-slits more than 5 times eye-diameter .... *bogimba*.

TABLE I

BIOMETRICS OF SWAIN REEFS WHALER SHARKS: measurements in mm.								N.S.W. Specimen
		Galeolamna	*coongoola* Holotype	*bogimba*	*stevensi*	*coongoola* Allotype	*stevensi*	*bogimba*
		Specimen. Australian Museum registered no.	IB.6006	IB.6007	IB.6008	IB.6009	IB.6010	IB.6352
H.	1	Length of Head to First Gill-Slit	195	..	310	280	206	560
	2	Length of Head to Last Gill-Slit	238	600	460	340	240	690
	3	Tip of Snout to Anterior Margin of Eye	90	..	120	126	90	237
	4	Breadth of Snout Immediately before Eyes	102	..	200	170	108	360
	5	Snout to Origin of Pectorals	224	..	470	365	250	660
	6	Snout to Origin of Ventrals	485	..	..	710	490	?
	7	Eye—Horizontal Diameter	22	Circa 27	30	26	21	25
	8	Eye—Vertical Diameter	16.5	20	20	22	20	26
	9	Interorbital Width	107	..	..	160	111	365
	11	Length of Nostril	14	36	25	23	16	40
	12	Internarial, between Posterior Angles	59	180	120	89	60	180
	13	Preoral Length	74	..	114	105	77	180
	14	Width of Mouth, between Angles	83	..	180	152	97	380
	15	Labial Fold—Upper	2	..	10	6	3	20
	16	Labial Fold—Lower	3	..	5	4	3	20
	17	Height of First Gill Opening	27	..	50 to 60	51	32	140
	18	Height of Last Gill-Opening	21	..	35 to 40	43.5	22	90
B	1	Length, Snout to Upper Caudal Pit	680	1940	1460	1075	685	c. 2030
	2	Length from Snout to Middle of Vent	492	..	..	745	510	?
	3	Predorsal Length	323	800	565	460	310	c. 840
	4	Depth at Origin of First Dorsal Fin	144	..	330	230	165	?
	5	Breadth Below Origin of First Dorsal Fin	111	..	..	175	121	?
	6	Depth of Caudal Peduncle	34	..	80	48	34	130
	7	Breadth of Caudal Peduncle	30	..	..	46	32	..
	8	Claspers—Outer Margin	None	..	None	100	None	..
	9	Claspers—Inner Margin to Membrane at Base	None	260	None	132	None	..
		Interdorsal Ridge	None	None	Present	None	Short	None

	Dental Formula	14.14 / 14.1.14	13.1.13 / 12.1.12	14.1 or 2.15 / 14.2.14	14.1.14 / 14.1.13	14.1.(? damaged) / 14.1.14	13.1.13 / 12.1.12
F. 1	First Dorsal Fin—Anterior Margin	115	330+ (tip missing)	310 +	170	121	370 tip incomplete
2	,, ,, Base	83	290	260	125	86	310
3	,, ,, Last Ray	40	82	45	55	38	90
4	Interdorsal Space	196	560	445	330	201	570
5	Second Dorsal—Anterior Margin	45	130	90	54	46	150
6	,, ,, Base	36	100	92	57	36	140
7	,, ,, Last Ray	43	53	70	54	42	90
8	Second Dorsal to Caudal Pit	66	circa 180	131	107	70	190
9	Anal Fin—Anterior Margin	62	? (worn down)	127	63	63	185
10	,, Base	40	..	90	53	37	120
11	,, Last Ray	40	..	70	47	38	82
12	Anal Base to Caudal Pit	55	..	117	95	68	130
14	Pectoral Fin—Length	182	500	370	250	177	570
15	,, Base	50	190	130	83	51	190
16	Origin of Pectoral to that of Ventral	265	760	560	387	260	?
17	Ventral Fin: Length of Anterior Margin	47	145	120	72	48	170
18	,, Base (to Outer Angle of Clasper if Present)	30	177	120	97	46	155
19	,, Length of Last Ray (Superiorly)	20	75	65	26	30	110
20	Ventral Origin to Anal Origin	108	..	....	208	103	360
21	Caudal Fin: Upper Lobe	251	620	520	355	258	685
22	,, Lower Lobe	127	310	230	185	133	360
	Sex	Female	Male	Female	Male	Female	Female
	Total Length	3 ft. 1 in.	8 ft. 4 in.	6 ft. 7 in.	4 ft. 9 in.	3 ft. 1¾ in.	9 ft.
	Weight in lb.	10	295	110	41	11	?
	Locality and Date	Gillett Cay 14.x.62	Gillett Cay 15.x.62	Gillett Cay 17.x.62	Capre Cay 22.x.62	Capre Cay 24.x.62	Middle Harbour Sydney 29.i.63

Genus **Galeocerdo** Muller and Henle, 1837

Galeocerdo cuvier (Le Sueur)

Squalus cuvier Le Sueur, 1822, *J. Acad. Nat. Sci. Philad.* 2: 351. North-western Australia.

A large female Tiger Shark was hooked at Capre Cay, 23.x.62. Total length, 11 ft. 4 in. Standard length, 8 ft. 9 in. Upper caudal lobe, 2 ft. 7 in. Lower caudal lobe, 1 ft. 4 in. Girth, 4 ft. 6 in. Pectoral fin, 18 in. Interdorsal, 33 in., strongly ridged.

The stomach contained *Lethrinus* (bait), birds' feathers and a piece of shark. There were no eggs or embryos. A healed bite-mark on left pectoral fin.

Loc.—Capre Cay, Swain Reefs, October 23, 1962. Austr. Mus. regd. no. IB.6011.

Family **Solenichthyidae**

Genus **Solenichthys** Bleeker, 1865

Solenichthys leptosomus (Tanaka)

Solenichthys leptosoma Tanaka, 1908, *Annot. Zool. Japon.* 7: 29, fig. Sagami Sea, Japan.

Solenostomus leptosomus Jordan and Thompson, 1914, *Mem. Carneg. Mus.* 6: 237.

Solenichthys leptosomus Whitley, 1952, *Proc. Roy. Zool. Soc. N.S. Wales*, 1951-52: 30, fig. 8. *Id.* Whitley and Allan, 1958, Sea-horse and its relatives: 62-64, fig. 18 no. 1. *Id.* Whitley, 1962, *Mar. Fish.* 1: 43, fig.

A living specimen of this remarkable fish, first described from Japan, since found in New South Wales, and now to be recorded from Queensland for the first time, was found floating at the anchorage. It appears to swim on one side, not upright, and can twist laterally so that the caudal fin can sweep around to near the snout. The first dorsal and the ventral fins move together, more like ventral fins on opposite sides of a normal fish.

One (IB.6012). Gillett Cay, October 14, 1962. New record for Queensland.

Family **Syngnathidae**

Genus **Micrognathus** Duncker, 1912

Micrognathus boothae, sp. nov.

Fig. 3

D. 21; A. 2; P. 11; C. 7. Rings 14 + 42; sub-dorsal 1 + 5.

Head (10 mm.) 17, depth of body (4.5) 38 in total length (170). Preanal and predorsal length, 50 mm.; dorsal base, 15; snout, 3; eye slightly shorter than snout; length of caudal fin, 3 mm.

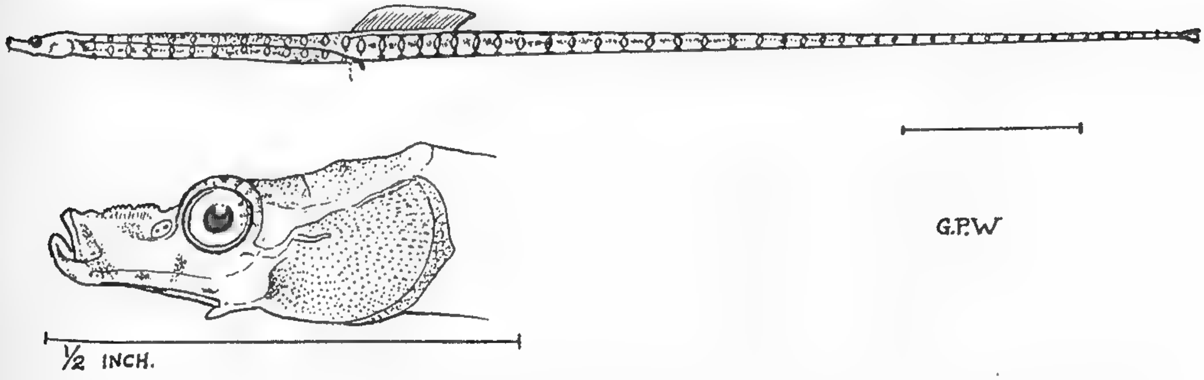


Figure 3.—Pipefish, *Micrognathus boothae*, sp. n. Holotype. Lord Howe Island.

Snout deep, its axis not tilted in relation to rest of head. Interorbital concave, broadening posteriorly. Supraorbital ridge not confluent with a high, serrated ridge over snout. This crest is divided into three adjacent portions, the first an entire convexity, the second and third with several serrae. Orbit cutting upper profile; occipital profile gently rising. A very short opercular keel from which broken radii spread across operculum.

Body seven-angled, tail quadrangular in cross-section. Trunk (43 mm.) about one-quarter of length. Tail more than twice as long as head plus body. Superior ridges of thorax converge towards end of dorsal base, not continuous with upper ridges of tail which extend forward to above vent. Median ridge of thorax continuous with lower ridge of tail. Inferior ridges of thorax ending each side of vent. A weak ventral keel on thorax. Conforms to Duncker's scheme no. 5. Edges of shields not spinose. Scutella oval. No brood-pouch in this specimen, probably subcaudal in male. No cutaneous appendages or cirri.

Dorsal origin opposite vent, its base extending over almost six tail-rings, not elevated. Anal minute. Pectorals and caudal fin small.

Colour in alcohol very pale yellowish-brown, the rings irregularly or partially outlined with light reddish-brown markings, often flecked with small light spots, the effect being rather chain-like. The median line of the chin is plain but on each side there are less than 10 rusty spots; ill-defined reddish-brown marks occur on the top and sides of the head. Pairs of rusty spots along ventral surface of body. Caudal light brown and white; other fins white. Eye blue with outer margin flecked with brown.

Described and figured from the unique holotype, 170 mm. or $6\frac{3}{4}$ in. in total length (Austr. Mus. regd. no. IB.5992).

Loc.—Far Rocks, Lord Howe Island, South Pacific; September, 1962. Collected and presented by Miss Julie Booth, after whom I have pleasure in naming the species. Miss Booth has presented many interesting fishes to the Australian Museum from New South Wales and Lord Howe Island.

To Herald's key to *Micrognathus* spp. [1953, *U.S. Nat. Mus. Bull.* 202 (1): 258] add "3*c*. Tail rings more than forty", to distinguish this new species from its congeners.

Genus **Hippocampus** Rafinesque, 1810

Hippocampus Rafinesque, 1810, *Caratt. Alc. Gen. Spec. Sicil.*, April, 1810: 18. Type-species, *Syngnathus hippocampus* Linne, by tautonomy and monotypy.

A list of the species of the world in the genus *Hippocampus* was given by Whitley and Allan (1958, The Sea-horse and its relatives: 37-42). A very beautiful new species was obtained by the Australian Museum 1962 Swain Reefs Expedition, which differs from all those known, by its zebra-like striped coloration and the combination of characters described below. The terms used are as defined by Ginsburg (1937, *Proc. U.S. Nat. Mus.* 83: 501) whose methods of measuring are also followed here.

Hippocampus zebra, sp. nov.

Plate 8

D. 17; A. 4; P. 16. Subdorsal rings 2 + 2. Eleven trunk-segments and about 37 tail-segments, but the ridges between the latter are obsolete posteriorly. Length from tip of tail to tip of coronet, 80 mm. Tail, 48 (i.e., 60% of length). Trunk, 29 (36%). Greatest depth (just behind dorsal origin), 14 (17.5%). Head, 21 (26.2%) Orbit, 4 (5%). Preorbital, 7 (8%). Snout, 10 (12%).

Coronet fairly high, preceded by a slightly granulose boss and bearing a crown of six backwardly curved, blunt spines. Profiles concave. A high spine over each eye. Snout more than half head, rising steeply over nostrils. Nuchal plates forming a ridge, irregularly outlined and slightly granular. Slightly rugose ridges along each side of snout and hyomandibular. Operculum with a slight tubercle from which striae radiate. A low spine halfway between eye and gill-opening. Four tubercles behind branchiostegal region on first trunk-segment. Four much smaller ones across chin just behind lower jaw. A median ventral keel on posterior trunk-segments. Trunk-segments septangular in cross-section. First caudal segment five-angled, rest four-angled in cross-section. Tubercles not stump-like but well developed, especially along dorso-lateral ridge, with a tendency to enlargement at intervals; three rather large tubercles each side of dorsal fin. Upper ridges of trunk and those of tail overlapping on two segments. Dorsal base elevated posteriorly. Skin smooth, without filaments, not even on tubercles, and without pimple-like excrescences. The absence of a brood-pouch indicates that the specimen is female. Tip of tail blunt, complete, not regenerated.

The coloration consists of yellowish-white and dark brown bands, most of them transverse, but some oblique or curved on the head and belly, as shown in the figure (plate 8), the whole forming a very beautiful and strongly contrasting arrangement with a tendency for broad and narrow bands to alternate. Eye blue with yellowish-white iris. Chin yellowish-white, without dark bands. Fins lighter; dorsal and anal fins brown proximally.

Described and figured from the holotype of the species, a specimen 94 mm. in total length when forcibly extended. Australian Museum registered no. IB.6015.

I am grateful to Mr. Anthony Healy for his photographs of the fish when fresh.

Loc.—Off Gillett Cay, Swain Reefs, Queensland; dredged in 38 fathoms on the afternoon of October 19, 1962. Australian Museum 1962 Swain Reefs Expedition.

A smaller female paratype (no. IB.2819) is in the Australian Museum from Moreton Bay, Queensland, collected by Mr. T. C. Marshall, June 6, 1952, received by exchange from the Dept. of Harbours and Marine, Brisbane, whose number 1630 it had been. The paratype agrees well with the holotype but the coronet has only two low tubercles, there are 21 dorsal rays and 17 pectoral rays and 41 tail-segments.

Apparently nearest *Hippocampus planifrons* Peters, 1877, and *mannulus* Cantor, 1850, but distinguished from both by its coloration and higher coronet.

Family **Apogonidae**

Genus **Pristiapogon** Klunzinger, 1870

Pristiapogon snyderi (Jordan and Evermann)

Plate 9

Apogon snyderi Jordan and Evermann, 1903, *Bull. U.S. Fish. Comm.* 22: 180 and 1905, *ibid*, 23: 214, pl. 36 and text-fig. 85 (q.v. for synon.). Honolulu. And of most later authors.

Amia snyderi Jordan and Seale, 1906, *Bull. U.S. Bur. Fisher*, 25, 1905: 237.

Pristiapogon snyderi Jordan and Jordan, 1922, *Mem. Carneg. Mus.* 10 (1): 42. *Id.* Herre, 1936, *Field Mus. Zool. Ser.* 21: 134. *Id.* Smith, 1961, *Ichth. Bull.* 22: 390, pl. 49, fig. B.

One specimen has the following characters:—

D. vii/i, 9 (10); A. ii, 8 (9); P. i, 12. L.lat. 25. Tr. 2/1/7. Predorsal sc. 4. Gill rakers 1, 3 + 1 + 12, 2.

Head (41 mm.) 2.4, depth (39) 2.6 in standard length (103). Eye, 12 mm.; interorbital, 10; snout, 10; maxillary, 19; longest dorsal spine, 18; height of second dorsal fin, about 23; of anal, 21; length of pectoral, 26; of ventral, 25; length of caudal peduncle 28.5, its depth, 16 mm. Maxillary reaches half-way below eye. Interorbital flat, porous. Villiform teeth in a boomerang-shaped patch on vomer, others on palatine; those of jaws in bands, none enlarged. Suborbital and both limbs of preopercle serrated.

Scales of l.lat. same size as those above and below it, l.lat. complete. No silvery glandular tubes. Scales ctenoid, adherent. Two scales between vent and anal fins and two between the dorsal fins.

Fourth dorsal spine slightly the longest. Caudal forked, without procurrent spines.

General colour in alcohol, horn-yellow. Each scale with light centre and greyish-brown margin. A dusky bar along snout before eye. Opercle dark brown. A dark brown saddle-like blotch on upper part of caudal peduncle posteriorly. A dusky lateral bar on body. Pectoral axil dark brown. Fins bone-yellowish: pectorals plain; dorsals with much dark brown infuscation; blackish-brown bars near soft dorsal and anal bases and along upper and lower caudal edges and along anterior ventral rays. Eye blue. Inside of mouth and gill-chamber yellowish.

Described and figured from a specimen (Austr. Mus. regd. no. IB.4828), 103 mm. in standard length or $5\frac{1}{8}$ inches overall.

Loc.—Frederick Reef, Coral Sea. Dr. D. F. McMichael, aboard H.M.A.S. *Gascoyne*.

Near *A. norfolcensis*, Ogilby 1887, *Proc. Linn. Soc. N.S. Wales* (Ser. 2) 2: 99. Lord Howe Island, but when compared with the types of that species and a long series of other specimens is seen to differ in having the dark spot on the caudal peduncle spread over the upper half of the peduncle, not restricted to a round spot on the l.lat. and has a blackish bar towards the base of the anal fin instead of a diffuse dusky front lobe to that fin as in typical *norfolcensis*. In these respects too its differs from *trimaculatus* Cuv. & Val. (1828, *Hist. Nat. Poiss.* 2: 156, pl. 22. Bourou, Moluccas).

Pristiapogon diversus, comb. nov.

Plate 10, upper figure

Amia diversa Smith and Radcliffe, 1912, *Proc. U.S. Nat. Mus.* 41: 434, pl. 37, fig. 1. Luzon, Philippines. *Id.* Schultz and others, 1953, *U.S. Nat. Mus. Bull.* 202: 441.

D. vii/i, 9 (10); A. ii, 8 (9); P. 14. L. lat. 25 to hypural. Tr. 2/1/7. Predorsal sc. $2\frac{1}{2}$. 18 slender, spinose gill-rakers on lower limb of first gill-arch.

Head (32 mm.) 2.7, depth (31) 2.8 in standard length (89). Eye 11 mm.; interorbital, 9; snout, 7; maxillary, 16; depth of head, 16; body-width, 17; longest dorsal spine, 14; height of second dorsal fin, 20; of anal, 15; length of pectoral, 24; of ventral, 19; length of caudal peduncle, 19; its depth, 12 mm.

Maxillary reaching half-way below eye. Chin jutting. Tongue rounded, scoop-like. Villiform teeth on jaws and in a V-shaped patch on the vomer, none on palatine. Interorbital flat, partly occupied by predorsal fans. Both limbs of preopercle serrated. Suborbital entire. Opercular scales large, operculum with long, flat spine. Two rows of cheek-scales. Orbital rim serrated behind and below.

Scales mostly very finely ctenoid, some deciduous. L.lat. complete, its scales the same size as those above and below it. Suprascapula entire, covered by scales. No silvery glandular tube. Vent near anal fin. Two scales between the dorsal fins.

Fourth dorsal spine longest. First spine goes about $3\frac{1}{2}$ times in second spine of dorsal. Second anal spine (11 mm.) about one third of head. Soft dorsal margin concave, anal slightly so. Caudal forked, without procurrent spines.

Colour in alcohol very pale yellow with silvery reflections. A brown bar from eye to tip of lower jaw. A conspicuous black spot on two lateral line scales on each side of caudal peduncle. Upper and lower caudal margins blackish. Fins pale yellow except for some blackish infuscations in front of either dorsal fin. Eye bluish grey with pale yellow iris with a blue smudge above iris. Inside of mouth and gill-chamber pale yellow.

Described and figured from a specimen (Austr. Mus. regd. no. IB.4993), 89 mm. in standard length or at least $4\frac{1}{4}$ inches overall (tail-tips are damaged).

Loc.—Kenn Reef, Coral Sea. October 2, 1960. Dr. D. F. McMichael, aboard H.M.A.S. *Gascoyne*.

Genus **Lovamia** Whitley, 1930

Lovamia Whitley, 1930, *Mem. Q'land. Mus.* 10: 10. Orthotype, *Mullus fasciatus* White, 1790.

Lovamia properupta, sp. nov.

Plate 10, lower figure

D. vii/i, 9; A. ii, 8; P. 13. L.lat. 27. Tr. 2/1/7. Predorsal scales 3. Gill-rakers 4 + 1 + 15 = 20 on first arch.

Head (21 mm.) 2.47, depth (19) 2.7 in standard length (52). Eye, 8; interorbital, 5 equals snout (5); maxillary, 10: depth of head, 16; breadth of body behind opercle, 9; longest dorsal spine, 10; length of pectoral, 14; length of caudal peduncle, 16; its depth 7.

Anterior nostril with small rim, posterior elongated pear-shaped. Maxillary emarginated, reaching below posterior half of eye. Villiform teeth in bands on jaws. No canines. Palatine teeth cannot be distinguished. A U-shaped band of fine teeth on vomer with the ends of the U expanded and turned outwards. Tongue spoon-like. Orbital rim slightly roughened supero-posteriorly. Suborbital entire. Posterior margins of preoperculum serrate, anterior margins smooth. Two rows of cheek-scales.

Body rather robust, its breadth less than half its depth, covered with thin but strong ctenoid scales, their serrations in more than one row. Lateral line complete, its scales about the same size as those above and below it. Suprascapula covered by scales. One or two scales between dorsal fins. No glandular peritoneal tube. Vent about halfway between ventral base and origin of anal fin.

Third dorsal spine longest, first very small, about one-third of second. Second anal spine (7 mm.) one-third of head. Margins of soft dorsal and anal fins sinuous. Ventrals pointed. Caudal forked, with very weak procurrent spines.

Colour in alcohol pale horn-yellow, the fins very pale yellow, almost white. No dark spot at base of tail. There are longitudinal brown stripes on head, body and dorsal fins, conspicuous on the head but faint elsewhere, wider than their light interspaces on the snout but not so behind the eye, and disposed as follows:—

(1) The first stripe runs half-way along posterior dorsal rays and is broken up into a row of dark patches on the membranes; (2) a dark band of varying intensity along each side of dorsal fins; (3) a row of dark-edged scales one scale-row below no. 2 and extending to upper caudal base; (4) a Y-shaped dark mark on top of head, the stem of the Y beginning at about level of nostrils, dividing over interorbital and each fork of the Y dividing to form a further Y-shaped mark at posterior level of eye and stretching over the nape; there is a V-shaped mark connecting the eyes anteriorly and passing over the snout, this is attenuated over the eye to continue as a brown band leading to (5), a faint dusky stripe along lateral line to upper half of caudal peduncle when it dips down to converge towards (6), a similar band from snout to opercle and below middle of side rising on caudal peduncle to converge towards no. 5—neither crosses the caudal fin. Between nos. 5 and 6 is a short stripe anteriorly from eye reaching only to end of postorbital. The chin is dusky and under the eye appears stripe (7) which runs to the lowest part of the operculum. Upper axil of pectoral brown-speckled. All ventral surface uniformly pale, also inside of mouth.

Described and figured from the unique holotype of the species, 2½ inches overall. Australian Museum registered no. IB.4852.

Loc.—Frederick Reef, Coral Sea; coll. Dr. D. F. McMichael, 1960.

Differs from other species in the disposition of the colour bands, notably in that the lateral ones converge on the base of the caudal fin, without a median stripe between them, there is a Y-shaped mark on top of the head whose prongs point backwards and each of which divides into a further Y-shaped mark and there is a dark stripe below the eye to edge of opercle.

Keys down to *novemfasciata* in Radcliffe (1911, *Proc. U.S. Nat. Mus.* 41: 246) but the banding is quite different and the pectoral base is light in my species. McCulloch's key (1915, *Biol. Res. Endeavour* 3 (3): 116) elaborated on Radcliffe's but again will not fit the Coral Sea fish, neither will Lachner's key (sections 19 and subdivisions, in Schultz, 1953, *U.S. Nat. Mus. Bull.* 202 (1): 439).

Genus **Apogonichthys** Bleeker, 1854

Apogonichthys Bleeker, 1854, *Nat. Tijdschr. Ned. Ind.* 6: 312 and 321. Type-species, *A. perdix* Bleeker

Apogonichthys coggeri, sp. nov.

Fig. 4

D. vii, i, 9; A. ii, 8; P. 20; V. i, 5; C. 15 main rays + shorter ones above and below. L.lat. 24. Tr. 1½/1/7. Predorsal, 5 scales. Gill-rakers 14.

Head (14 mm.) 3, depth (18) 2.3 in standard length (43). Predorsal length, 20 mm.; maxilla, 8; snout, 3; eye, 4; interorbital, 3; length of pectoral fin, 12; length of caudal fin, 14; depth of caudal peduncle, 8.

Head striated above. Nostrils round, without papilla, only low rim. A slender opercular spine. All opercles and orbital rim entire. Maxillary truncate, reaching beyond eye. Lower jaw very slightly the longer. Minute villiform teeth on jaws and vomer (none on palatines). Vomerine teeth in medium triangular patch. No canines. Tongue rounded, scoop-like. Six slender and six pad-like (rudimentary) gill-rakers on lower portion of first branchial arch, plus 2 on upper portion. Small pseudobranch present.

Form compressed. Suprascapular entire, covered by scales. Scales adherent, papery, ctenoid. L.lat. complete and continuous, rather high on sides. Caudal peduncle about as deep as long and less than half head. No silvery, subcutaneous prolongation of peritoneum. Vent immediately before anal fin.

Third dorsal spine longest, longer than ventral or anal spines. Dorsal bases equal, greater than anal base. No interdorsal scales, the fins being connected at the base. Caudal rounded; its upper and lower rays not spinelike, upper rays shorter than lower ones.

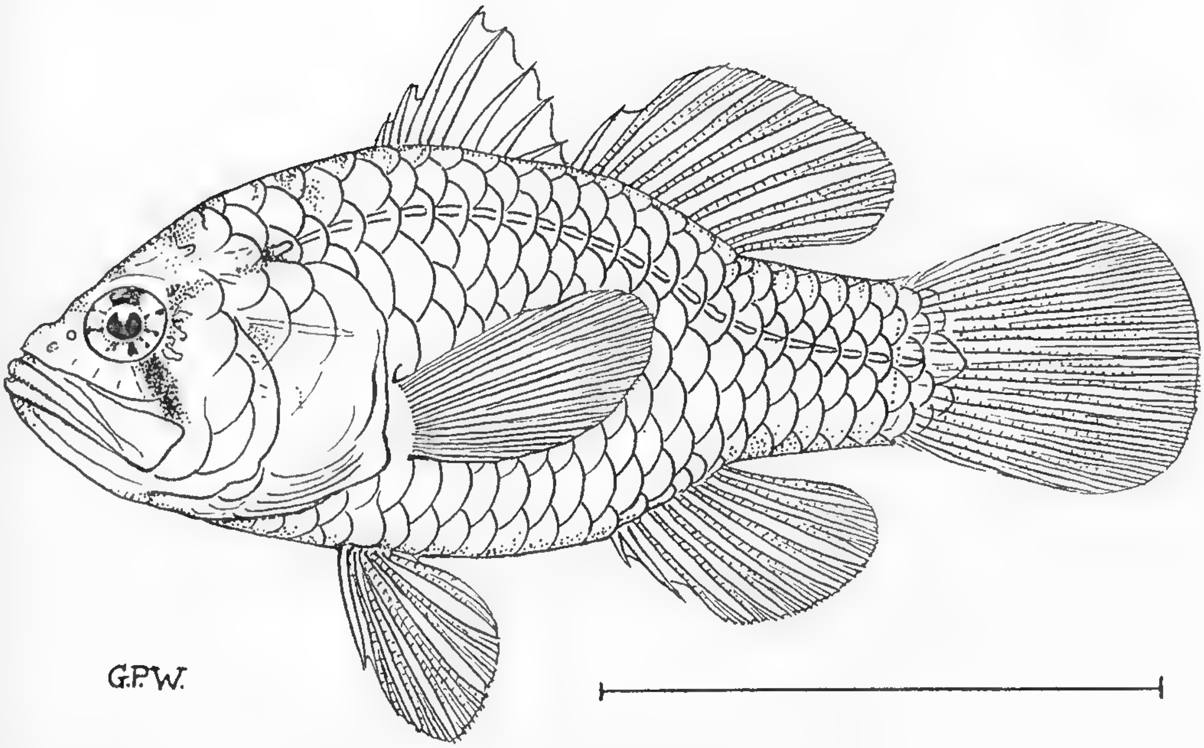


Figure 4.—Gobbleguts, *Apogonichthys coggeri*, sp. n. Holotype. Gillett Cay.

Colour in life, pinkish yellow with white flanks and belly, slightly pellucid. Fins white to hyaline with brown along their bases. Pupil dark blue, iris silver with several pink and orange spots. Several brown marks, fringed by silver, radiate from eye. After death, and preservation in alcohol, the general colour changed to pale yellowish, with traces remaining of the dark radii from the eye. Inside of mouth pale yellow, not black.

In the field this fish did not have the usual facies of the Apogonidae but recalled rather the Chandidae or some other percoid family. Unusual appearances such as this generally indicate remarkable habits in fishes but no observations of the living fishes were made. Three examples were killed by rotenone in separate situations of the lagoon at Gillett Cay, Swain Reefs, on October 20, 1962. One had an isopod in its left gill-chamber and yellow eggs in its mouth, so buccal incubation is practised as in most Apogonidae.

Described and figured from the holotype (regd. no. IB.6016), 54mm. or $2\frac{1}{8}$ inches long, and two slightly smaller paratypes (IB.6017-8) in the Australian Museum.

Loc.—Gillett Cay, Swain Reefs, Queensland; October 20, 1962; Australian Museum 1962 Swain Reefs Expedition.

Not like any described species, characterized particularly by the compressed habit, weak dentition, form and formulae of fins and in having five predorsal scales.

Named after Mr. Harold George Cogger, a member of the expedition, who has on numerous occasions presented interesting fishes to the Australian Museum, where he is Curator of Reptiles.

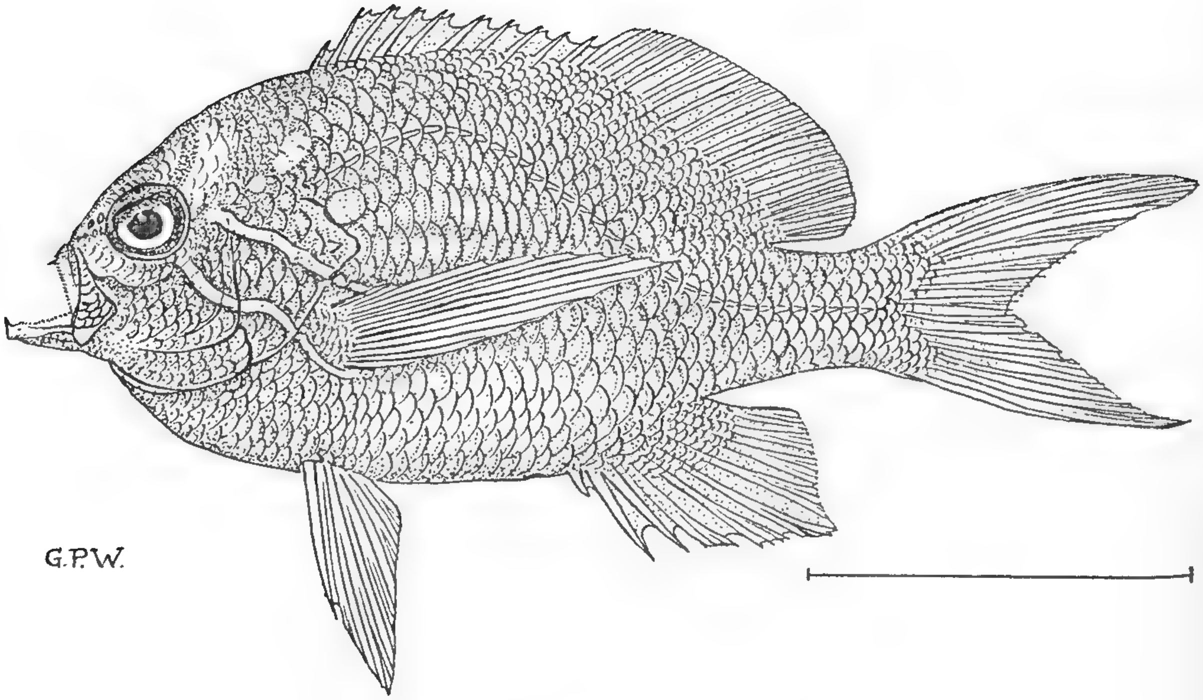


Figure 5.—Coral Perch, *Dactylanthias mcmichaeli.* Holotype. Lihou Atoll.

Family **Anthiidae**

Genus **Dactylanthias** Bleeker 1870

Dactylanthias mcmichaeli Whitley

Fig. 5

Dactylanthias mcmichaeli Whitley, 1962, *N. Qld. Nat.* 30 (131): 3, fig. 1.

Here figured from the holotype from Lihou Atoll, Coral Sea; D. F. McMichael, 30.ix.60.

Genus **Mirolabrichthys** Herre, 1927

Mirolabrichthys Herre, 1927, *Philip. J. Sci.* 32 (3): 413 Orthotype, *M. tuka* Herre. *Id.* Myers, 1929, Copeia 1929: 1. *Id.* Fowler, 1931, *Bull. U.S. Nat. Mus.* 100 (11): 226. *Id.* Weber and Beaufort, 1936, *Fish.Indo-Austr.Archip.* 7: 321. *Id.* Herre, 1955, Copeia 1955: 224. *Id.* Smith, 1955, *Ann.Mag.Nat.Hist.* (12) 8: 345. *Id.* Smith, 1957, Copeia 1956: 251.

Entonanthias Jordan and Tanaka, 1927, *Ann.Carneg.Mus.* 17: 385. Orthotype, *E. pascalus* Jordan and Tanaka. *Id.* Tanaka, 1927, *Fish. Japan* 41: 800, pl. 162, fig. 474.

Mirolabrichthys tuka pascalus (Jordan and Tanaka)

Fig. 6

D.x, 15 (16); A. iii, 6 (7); P. i, 17; V. i, 5; C. 14 branched rays. L.lat. 50. Tr. $5\frac{1}{2}/1/16$ to 6/1/6 on caudal peduncle. 15 scales between l.lat. and origin of anal.

Head (30 mm.) 3.6, depth (37) 2.9 in standard length (108). Depth of caudal peduncle, 15. Eye (6) shorter than snout (7) and interorbital (9). Maxilla 16, its greatest depth, 4.1 mm. Predorsal length 32.

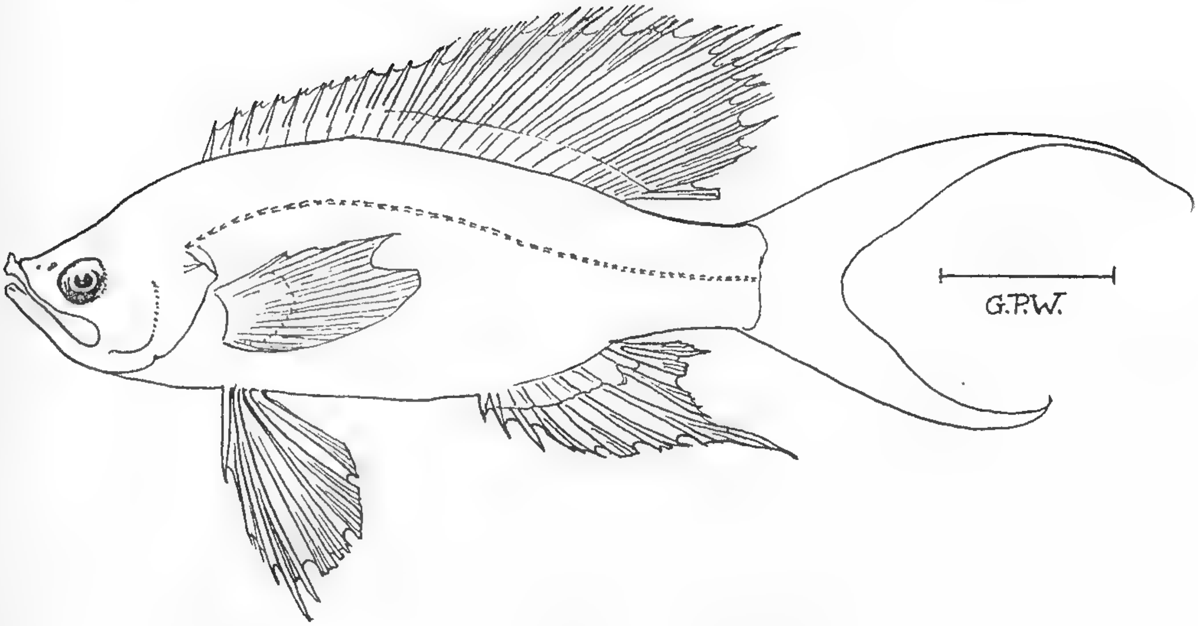


Figure 6.—Sea Gourami, *Mirolabrichthys tuka pascalus.* Lihou Atoll.

Form rather suggestive of a gourami, elongate-oval, rounded in transverse section of body anteriorly and compressed posteriorly. Upper profile of head concave over eyes and convex before dorsal; lower profile straight. Upper lip terminal, produced upwards. Tongue fleshy with an acutely pointed tip. Tongue toothless.

Fine conic teeth in jaws mostly in a single main row but with a few inner ones amongst the inner band of villiform teeth, broadly interrupted at the symphysis. A canine on each side of upper jaw anteriorly. A pair of canines on each side of front of lower jaw, deflected outwards and fitting into depressions in upper jaw. One or two backwardly directed fangs on each side of lower jaw. Mandibulary ramus steeply sloping. Many long, slender gill-rakers. Pseudobranchiae present. Isthmus narrow and trenchant.

Head scaly, including snout. Eye low in relation to the broad, very convex interorbital, upper margin of eye on level of upper lip, posterior margin of orbit crenulated. Maxilla broadly rounded, scaly, reaching below hind part of eye, without supplemental bone; only sheathed anteriorly. Suborbital shallow. Posterior margin of preoperculum serrate. lower limb smooth, without any antrorse spine. One exposed opercular spine on each side.

Nostrils round openings, posterior larger, somewhat pear-shaped.

Scapula exposed. Body entirely covered by imbricate ctenoid scales with some auxiliaries even on the lateral line. Lateral line complete, extending to caudal fin, its sensory tubes straight or with an ascending tubule extending along nearly the whole of each scale. Four rows of body-scales between lateral line and middle dorsal spines. Scaly sheaths to all fins.

Ten dorsal spines, increasing in length posteriorly to 12 mm. long. None of the spines produced. Rays branched.

Second dorsal and anal fins elevated with some produced rays; longest dorsal ray 39 mm. Second anal spine, 6.5 mm.; third, 10 mm.; fourth ray 35 mm. Pectorals as long as head, rays branched; third branched ray (28 mm.) longer than those below it until the eighth or ninth. Ventrals pointed, originating below lower pectoral insertion and reaching anal origin when adpressed. Caudal strongly forked, its lobes ending in filaments, upper one longer.

Colour, in preservative:—Most of upper half of fish bluish grey, darkest along back and as a series of chevron-like marks on the myomeres. Lower half yellow becoming white on snout, cheeks, chin and margin of operculum. A red mark on pectoral base. Pink tinge on breast. Fins very pale yellow, almost dull white. Eyes blue. Top of upper lip brown. A diffuse dusky blotch on opercle.

Described from a specimen 108 mm. in standard length, $4\frac{5}{8}$ inches to caudal fork, or $6\frac{3}{4}$ inches overall, collected by dropping explosives around deep holes or large coral masses in the lagoon at Lihou Atoll, Coral Sea; collected with *Caesio diagramma* by Dr. D. F. McMichael aboard H.M.A.S. *Gascoyne*, September 30, 1960. Australian Museum regd. no. IB.4810. A second, similar specimen (IB.4822) from Frederick Reef, Coral Sea; same collection.

Suggested vernacular name: Sea Gourami.

Similar to typical *Mirolabrichthys tuka* Herre and Montalban 1927 [*Philip. J. Sci.* 32 (3): 413, pl. 1] from the Philippines but differing in the gradual increase in length posteriorly of the dorsal spines, and in lacking the dark blotch on the spinous dorsal. In these respects it resembles *Entonanthias pascalus* Jordan and Thompson, 1927 (*Ann. Carneg. Mus.* 17: 385, pl. 34, fig. 2), from Okinawa, Japan, which is regarded by Fowler, 1931 (*U.S. Nat. Mus. Bull.* 100 (11): 226) as a synonym of *M. tuka*, though Myers, 1929 (Copeia 1929: 2) separated them. Another species was named *dispar* by Herre, 1955 (Copeia 1955: 224) from the Solomon Islands, with l.lat. 58. The notched pectoral outline, characteristic of the Coral Sea fish, is also shown in Tanaka's 1927 figure (*Fish. Japan* 41: 800, pl. 162, fig. 474).

Family **Carangidae**

Genus **Turrum** Whitley, 1932

Turrum emburyi Whitley

Turrum emburyi Whitley, 1932, *Rec. Aust. Mus.* 18: 337, pl. 38, fig. 4. North-West Island, Queensland. *Id.* 1962, Marine Fishes 1: 112 and fig.

A Turrum taken by handline on October 19, had the following characters:—

D. vii/29; A. ii/24; P. 20. L.lat. 13 scutes plus some smaller scales. Head, 160 mm.; depth at second dorsal origin, 170; maxilla, 62; eye, 28; preorbital, below eye, 30; snout, 70; length of pectoral fin, 214.

Teeth villiform, not enlarged. Gill-rakers 7/1/14 plus 3 to 4 rudiments. Maxilla reaching below front of eye.

Curved portion of l.lat. (250 mm.) greater than straight portion (202), the junction being below 18th dorsal ray. Lower half of breast naked; upper scaly, junction wavy.

Colour brilliant blue above, silvery below. Back and sides with four series of gold spots. Pectoral axil black. Grey blotch on operculum. Pupil black with yellow ring and bronze and yellow iris. Fins mostly olivaceous. Front of anal, most of ventrals and lower part of pectorals white; upper part of pectoral grey. A broken line of yellow marks at base of anal fin.

Described from a specimen 627 mm. L.C.F. or 700 mm. in total length. Weight 8 lb. Austr. Mus. regd. no. IB.6160.

Loc.—Gillett Cay: October 19, 1962.

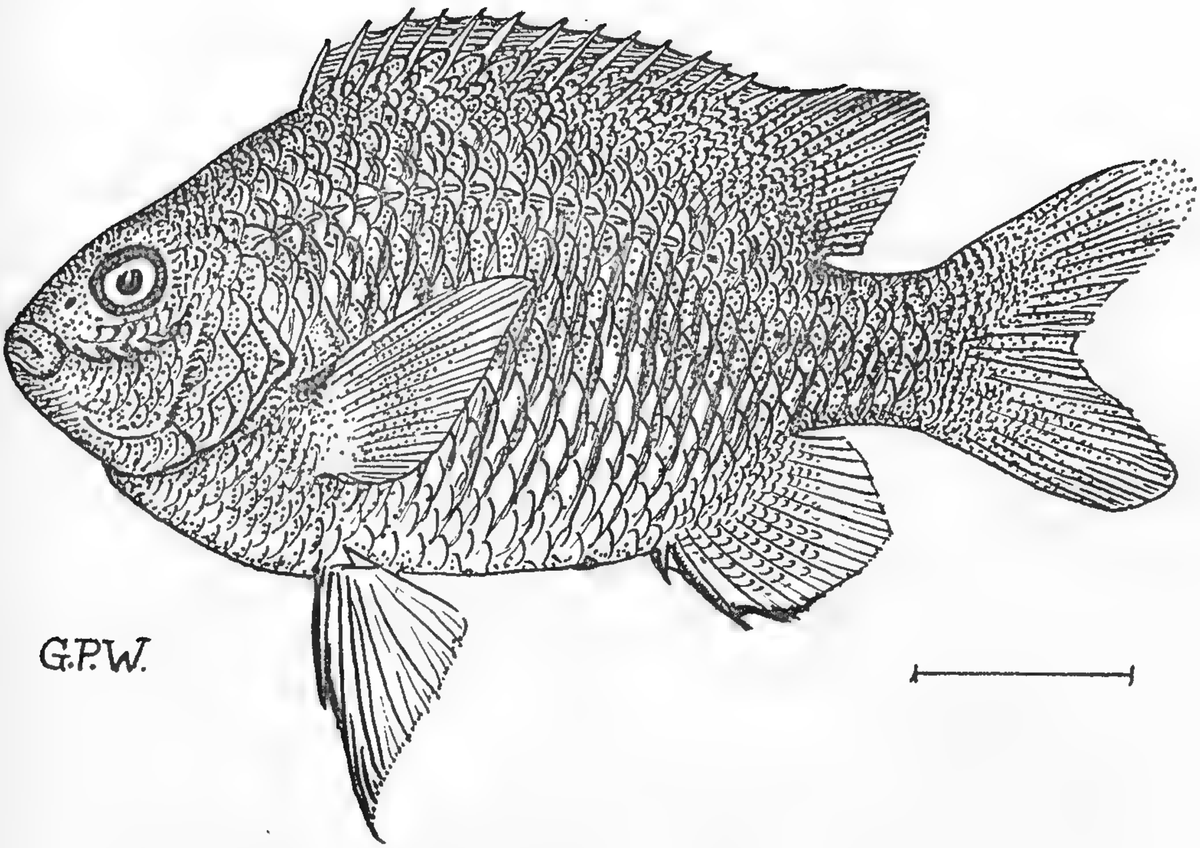


Figure 7.—Demoiselle, *Pseudopomacentrus gascoynei*, sp. n. Holotype. Kenn Reef.

Family **Pomacentridae**

Genus **Pseudopomacentrus** Bleeker, 1877

Pseudopomacentrus gascoynei, sp. nov.

Fig. 7

D. xiv, 15; A. ii, 13; P. i, 19; L.lat. 19 tubes. Sc. 27. Tr. 3/1/11. More than 20 predorsal scales. Head (33 mm.) 3.2, depth (55) 1.9 in standard length (107). Eye (8) less than snout (9) and interorbital (12). Maxillary, 8 mm.; length of ventral fin, 29; second anal spine, 17; length of pectoral 28.

Head scaly above to before nostrils, naked only on anterior parts of snout, preorbital and chin, where there are pores, and on mouth. Maxillary not reaching below eye. Teeth compressed, uniserial. Mandibular ramus very slightly raised. Suborbital serrate, not notched. Posterior preopercular limb serrate. Other opercles entire. Cheek-scales in three or four rows. A small, exposed opercular spine. Suborbital scales extend forward to below anterior part of eye. Interorbital roundly convex. Thirteen slender, spinose gill-rakers on lower part of first branchial arch.

Body deep, robust anteriorly, compressed posteriorly, covered with ctenoid scales with five or six basal radii and scored or pitted surfaces. Some auxiliary scales on head and shoulder-region. Scales, some lanceolate, extend thickly over bases of the fins, except ventrals, which have axillary scales.

Base of spinous dorsal much longer than that of soft; membrane not incised or pennanted. Fin-lobes rather rounded, except paired fins which are more pointed. Ventrals reaching vent.

Colour, in alcohol, dark greyish-brown, darkest on front of head, along back, dorsal fins and tail. Dark edges of scale-rows tend to form indistinct oblique, downward and forward-running stripes. Fins greyish-brown like the body but the ventrals and anal are mostly light yellowish with their anterior edges blackish. A small blackish spot at top of pectoral base; the axil and scaly base both light. No ocelli. Females are paler grey in ground-colour with dusky blotches on the body.

Variation: 15 to 17 dorsal, 13 to 14 anal and 18 to 19 pectoral rays. L.lat. tubes 18 to 21. About 5 to 7 pores along caudal peduncle. Sc. 25 to 27 and Tr. 3/1/11 to 13.

Described and figured from the holotype (Australian Museum registered no. IB.4987) evidently a male specimen, 107 mm. in standard length or $5\frac{3}{8}$ inches overall, also five male and two female paratypes (nos. IB.4856, 4950, 4984 to 4986, 4988 to 4989, all smaller than the holotype.)

Locs.—Reefs in the Coral Sea: Kenn Reef, October 10, 1960 (holotype and paratypes, IB.4984 to 4989), Frederick Reef (IB.4856); and Bird Islet, Wreck Reef, October 4, 1960 (IB.4950). Collected by Dr. D. F. McMichael, of the Australian Museum.

Recognizable from its congeners by the 14 dorsal spines, light ventral and soft anal fins with their front edges dusky, the oblique dusky bars down the body and other characters. In authors' keys it comes nearest the *tripunctatus*, *littoralis* and *wardi* group of species but is separable by fin- and scale-counts. *P. analis* Macleay has similar coloration but meristic differences.

Named after H.M.A.S. *Gascoyne*, from aboard which the new species was collected during a survey of the islands in the Coral Sea.

Pseudopomacentrus navalis, sp. n.

Fig. 8

D. xiii, 15 to 16; A. ii, 12 to 13; P. i, 19; l.lat. tubes 17 to 20. Sc. 24 to 27. Tr. 3/1/11 to 12. About 23 predorsal scales.

Head (28 mm.) 2.6 to more than 3, depth (52) 1.8 to more than 2 in standard length (94). Eye (7 mm.) equal to snout and less than interorbital (10). Maxillary, 7 mm.; length of ventral fin, 27; second anal spine, 16; length of pectoral, 26.

General characters as described for *gascoynei*. Two rows of suborbital scales. Teeth uniserial, compressed, with cutting edge not compact but with free points. Opercular spine not fully exposed. Eleven gill-rakers on lower part of first gill-arch. Some lateral line tubes very weakly developed. Scales with 8 to 10 basal radii. Ventrals not reaching vent.

Colour dark brown to black. Some with indistinct light grey spots along row of scales from ventral origin to near anal base. Eye greenish.

Described from holotype (IB.4970) and four paratypes (IB.4967-4969 and 4971), up to $4\frac{7}{8}$ inches in total length.

Loc.—Kenn Reef, Coral Sea; October 2, 1960. Dr. D. F. McMichael.

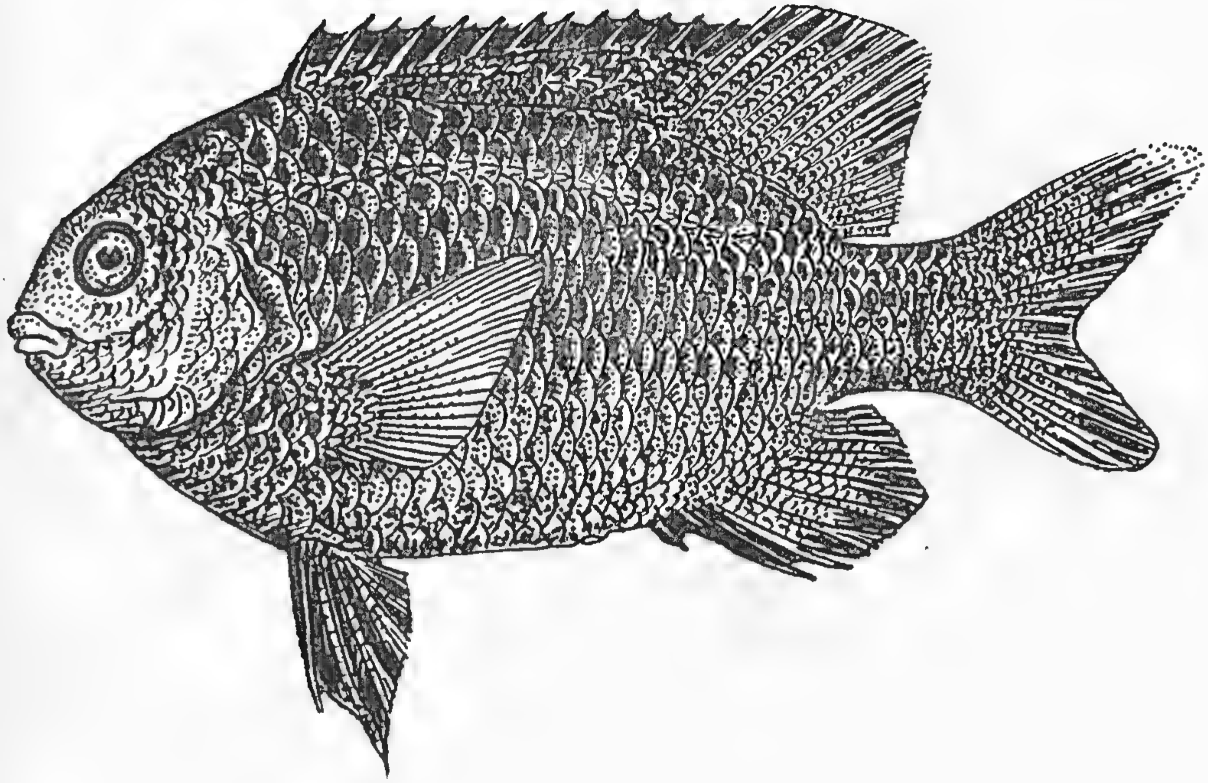


Figure 8.—Demoiselle, *Pseudopomacentrus navalis*, sp. n. Holotype, Kenn Reef.

Named *navalis* for the Royal Australian Navy, on one of whose surveys the specimens were collected.

Superficially like *Pseudopomacentrus gascoynei*, sp. n., but has black ventral and anal fins, and 13 dorsal spines.

Pseudopomacentrus imitator, sp. nov.

Fig. 9

D. xiv, 14; A. ii, 14; P. i, 17. L.lat. 18. Sc. 24. Tr. 3/1/9. About 24 predorsal scales.

Head (23 mm.) 3.5, depth (43) 1.8 in standard length (80). Eye 7.5 mm., greater than snout, 6. Interorbital, 8; maxillary, 6; length of pectoral, 26.5; of ventral, 20; second anal spine, 7.

General characters as in *P. gascoynei*, sp. nov. (page 173), except as follows. Mandibular ramus steeply elevated. Suborbital slightly notched, entire, naked. Maxilla below eye in young, not in larger specimens. Fifteen gill-rakers on lower limb of first branchial arch.

Dorsal spines rather short, increasing in height backwards and with long pencils and incised membranes. Fin-lobes rather pointed. Ventrals reaching anal spine.

Colour in alcohol dark brown, each scale with darker border. Top of head and back and most of fins blackish. Pectoral base black, with a light area behind this. Posterior part of caudal peduncle pale orange becoming dirty white on caudal fin. The light caudal area and the dark brown ventrals and anal as well as the black pectoral axil and base, further distinguish this species from *gascoynei*.

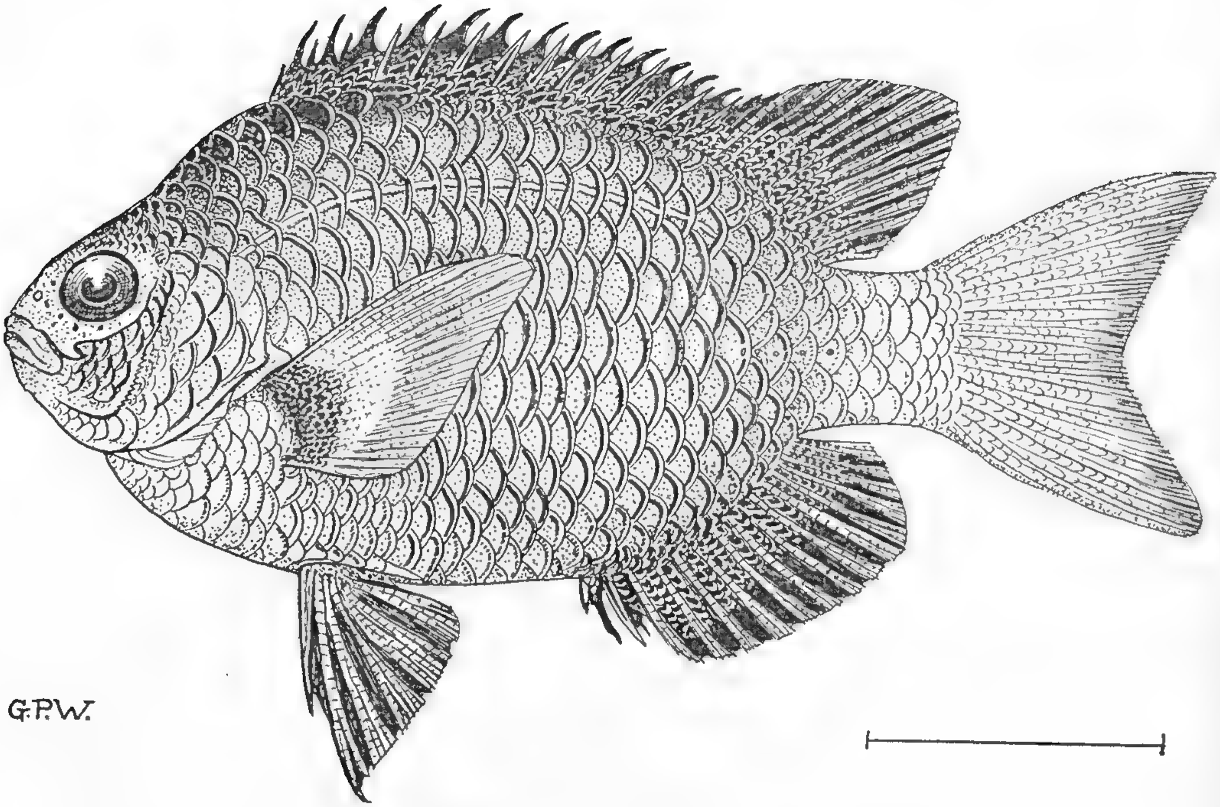


Figure 9.—Demoiselle, *Pseudopomacentrus imitator*, sp. n. Holotype. Lihou Atoll.

Coloration similar to that of *Lepicephalochromis westalli*, sp. nov. (page 180), but the dark colour of the body gradates into slightly lighter tail-region instead of being abruptly bounded, the pectoral axil is black and the upper and lower caudal lobes are not so dark. Nevertheless, mimicry between the two genera may be indicated.

Described and figured from the holotype (Austr. Mus. regd. no. IB.4945), a specimen 80 mm. in standard length or $4\frac{1}{8}$ inches overall, which is larger than three paratypes (IB.4908, 4909 and 4944) with identical data.

Loc.—Beyond the reef-crest, Lihou Atoll, Coral Sea; September 30, 1960 (Dr. D. F. McMichael).

Genus **Iredaleichthys** Whitley, 1928

Iredaleichthys glaucus (Cuv. & Val.)

Glyphisodon glaucus Cuvier & Valenciennes, 1830, *Hist. Nat. Poiss.* 5: 475. Guam.

Glyphidodontops modestus Bleeker, 1877, *Atlas. Ichth.* 9, pl. 403, fig. 9.

Iredaleichthys modestus Whitley, 1929, *Mem. Qld. Mus.* 9 (3): 242.

Abudefduf glaucus Okada and Ikeda, 1937, *Bull. Biogeogr. Soc.* Japan 7 (7): 74, pl. 5, fig. 1. *Id.* Fowler, 1959, Fishes of Fiji: 384, fig. 168. *Id.* Smith, 1960, *Ichth. Bull.* 19: 336, pl. 29, fig. F. And of recent authors.

D. xiii, 12; A. ii, 12; P. 1, 17; L.lat. 19. Sc. 23 to hypural joint Tr.. 3/1/9. Predorsal scales about 16.

Head (24 mm.) 3.2, depth (36) 2.1 in standard length (77). Eye 7 mm., interorbital, 7; snout, 6; maxillary, 8; length of pectoral fin, 18; of ventral, 19; second anal spine, 9; breadth of body (16). Base of spinous dorsal (35 mm.) much longer than that of soft (15), which is equal to that of anal fin. Height of second dorsal fin, 15 mm.

Eye rather small. Interorbital broadly convex. Predorsal scales end over front of eye. Cheek-scales in 3 rows. Preorbital and suborbital meeting at obtuse angle, about half depth of eye. Snout and preorbital naked, also lower preopercular flange. Suborbital and all opercles entire. Maxillary barely reaching below eyel Lips thick, normal. Teeth compressed with separate, chisel-like tips. Two opercular spines. About 16 long slender gill-rakers on lower portion of first branchial arch.

Form elongate-ovate. Lower profile more convex than upper. Body covere. with ctenoid scales, small ones of which extend over lower parts of unpaired fins bud do not form very dense sheaths; $1\frac{1}{2}$ rows of scales between last scales of l.lat. and dorsat sheath. About 12 basal radii. No auxiliary scales. Axillary scales at ventrals.

Membranes of first dorsal fin penicillate. Soft dorsal higher than the spinous. First two spines rather short, fifth and succeeding spines longest. Lobes of fins all rounded; pectorals rather short. Ventrals not reaching vent.

General colour in alcohol mostly pale lilac-greyish, especially on back, head, and on centres of body-scales; other parts pale yellowish-cream, especially over preorbital, lips, edges of opercles, branchiostegal region, isthmus, breast and paired fins. Dorsal fins dove-grey; anal and caudal fins pale dirty yellowish with narrow grey borders; vent black, eye blue. No ocelli, bands, stripes or notable markings. Pectoral axil and base white. Teeth golden.

Described from a specimen 77 mm. in standard length or 4 inches overall. Austr. Mus. regd. no. IB.4951.

Loc.—Bird Islet, Wreck Reef, Coral Sea, October 4, 1960; Dr. D. F. McMichael. Other specimens in the Australian Museum from the New Hebrides; Suva, Fiji, and Port Moresby, Papua. Occurs in Queensland.

Genus **Amblyglyphidodon** Bleeker, 1877

Amblyglyphidodon curacao (Bloch)

Chaetodon curacao Bloch, 1787, *Nat. Ausl. Fische* 3: 106, pl. 212, fig. 1. "Curaçao".

D. xiii, 13; A. ii, 15; P. ii, 17. L.lat. 16. Sc. 22. Tr. 4/1/10. About 22 predorsal scales. Gill-rakers 16 on lower part of first branchial arch.

Head (15 mm.) 3, depth (29) 1.5 in standard length (46). Eye, 6 mm.; second anal spine, 10.

Scales extending forwards to top and most of sides of snout. Preorbital and suborbital scaly, the latter free to behind eye. All opercles entire. Cheek-scales in two horizontal and seven transverse rows. Lips normal. Maxillary reaches below front of eye. Teeth slightly compressed with separate pointed tips. Mandibular ramus elevated.

Anterior profile gibbous at nape; concave to flat towards snout. Upper profile more convex than lower. Form deeply rounded, orbicular, strongly compressed. No auxiliary scales on body. Scales ctenoid, fine, with about seven basal radii. L.lat. ascending steeply at first, thence running with $1\frac{1}{2}$ scale-rows between it and the back. Scales extend over much of fins, except ventrals. L.lat. pores on caudal peduncle. Spinous dorsal membranes penicillate and deeply incised. Anal base (14 mm.) longer than soft dorsal base (9).

Colour in alcohol mainly brown above, yellow on the flanks and pearly white below. Mouth and chin dark-speckled. The brown is darkest on top of head and on an ascending patch just behind upper part of operculum. The dusky brown of the nape is carried down to the aforesaid patch and across the operculum and is associated with a brown streak bordering the preoperculum to descend to the throat as a brown band broken up into small spots. A lighter brown band descends from anterior part of spinous dorsal base to taper to just above the ventral fin. A similar band falls from farther back to fade out below just before the anal fin and a fainter shorter one descends about two-thirds of the distance between the soft dorsal and soft anal fins. Posterior part of second dorsal base brown. A small brown spot at pectoral origin; axil yellow. Spinous dorsal fin and first ray dark brown. Ventrals infuscated, also front half of anal. Other parts of all fins yellowish. Caudal plain. Central part of eye blue but before and behind the pupil the iris is silvery-green with a brown orbital rim. Inside of mouth white.

Described from a young specimen 46 mm. in standard length or about $2\frac{1}{2}$ inches overall (Austr. Mus. regd. no. IB.4906).

Loc.—Beyond reef-crest of Lihou Atoll, Coral Sea; September 30, 1960. Dr. D. F. McMichael.

Genus **Glyphisodon** Lacépède, 1802

Glyphisodon sordidus (Bonnaterre, 1788)

Chetodon sordidus Bonnaterre, 1788, *Tabl. Encycl. Meth. Ichth.*: 90. Red Sea (Forskal).

Fig. 10

D. xiii, 15; A. ii, 15; P. 19. L.lat. 22. Sc. 26. Tr. 4/1/11. Predorsal scales 14.

Head (9 mm.) 2.7, depth (13) 1.8 in standard length (25). Eye, 3 mm.; snout, 2; interorbital, 3; maxillary, 3; postorbital, 4; depth of caudal peduncle, 5; breadth of body, 4.5; length of pectoral, 7; of ventral, 8; second anal spine, 4; longest upper caudal ray, 8.

Maxilla reaching below front of eye. Teeth erect, not flared outwards; in single row, slightly compressed but with separated points. Mandibular ramus slopes very slightly upwards. Head scaly, except eyes, most of interorbital, snout, suborbital, middle of isthmus and around mouth. Suborbital free under most of anterior half of eye. All opercles entire. Three rows of cheek-scales. Preorbital naked. About 14 slender gill-rakers on lower portion of first branchial arch.

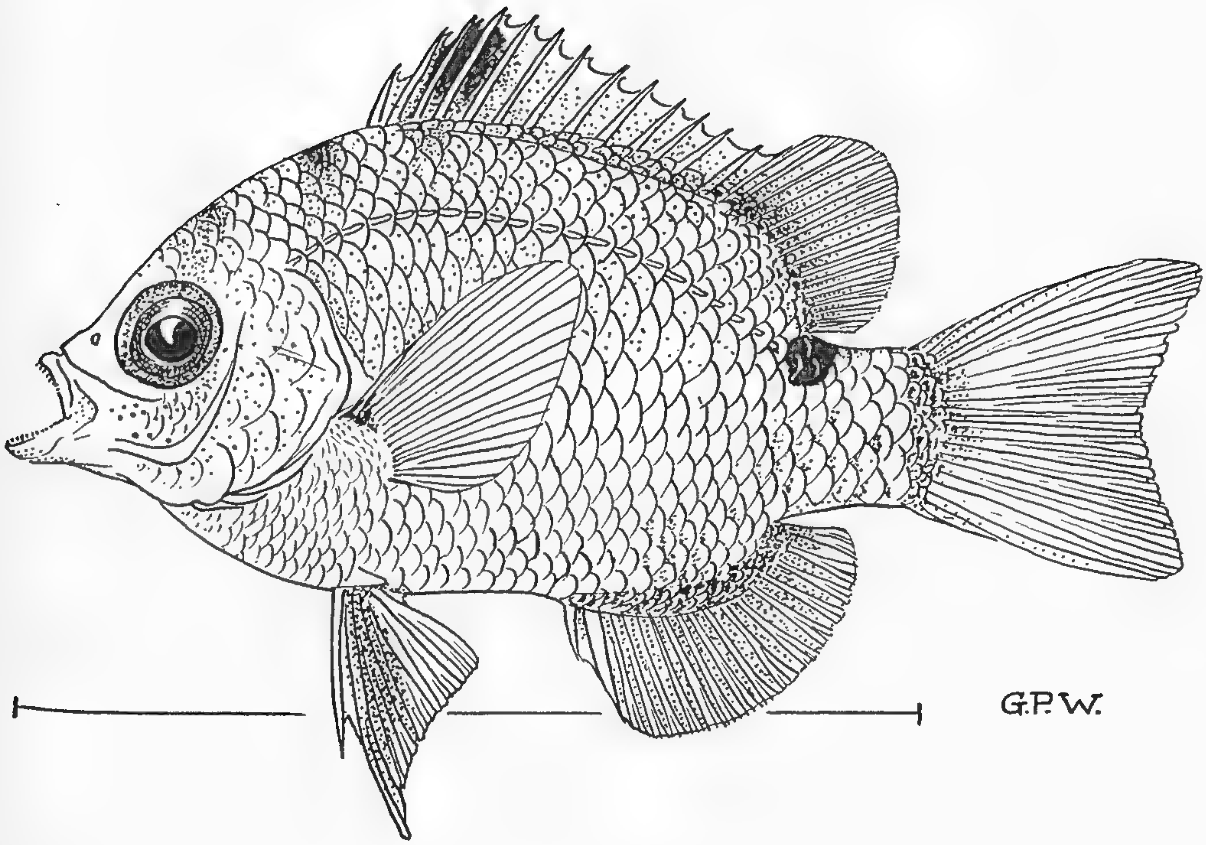


Figure 10.—Demoiselle, *Glyphisodon sordidus.* Juvenile from Lord Howe Island.

Form ovate, compressed, upper profile not much more convex than lower one. Greatest depth below front of first dorsal fin. Body covered with ctenoid scales with no auxillary scales. Between l.lat. tubes and back (dorsal sheath) are 3 rows of scales. L.lat. tubes to below posterior half of soft dorsal fin; pores along caudal peduncle absent. Scales extend on bases of all fins. Ventrals with axillary scales.

Membranes of spinous dorsal fin very slightly incised and pencilled. Base of first dorsal greater than that of second. Both fins of equal height. Anal base greater than soft dorsal base. Ventral ray reaching beyond second spine of anal. Caudal forked, upper lobe longer.

Colour in alcohol yellowish. Distal third of body faint grey. Black blotch over longest dorsal spines. Another on anterior and superior part of caudal peduncle. Slight infuscations on lips and before dorsal origin and a speckling of dusky chromatophores on head and body generally. Dorsal fins mostly dark grey, especially basally. Other fins lighter; pectorals almost white with dusky brown spot over upper part of base and axil light. Eye blue.

Described and figured from a juvenile specimen 25 mm. in standard length or about 1¼ inches overall. Australian Museum regd. no. IB.5517.

Loc.—Lord Howe Island; Miss Julie Booth, early 1962.

Distinguished by its coloration, naked anterior parts of head, low number of gill-rakers, slightly compressed teeth, &c.

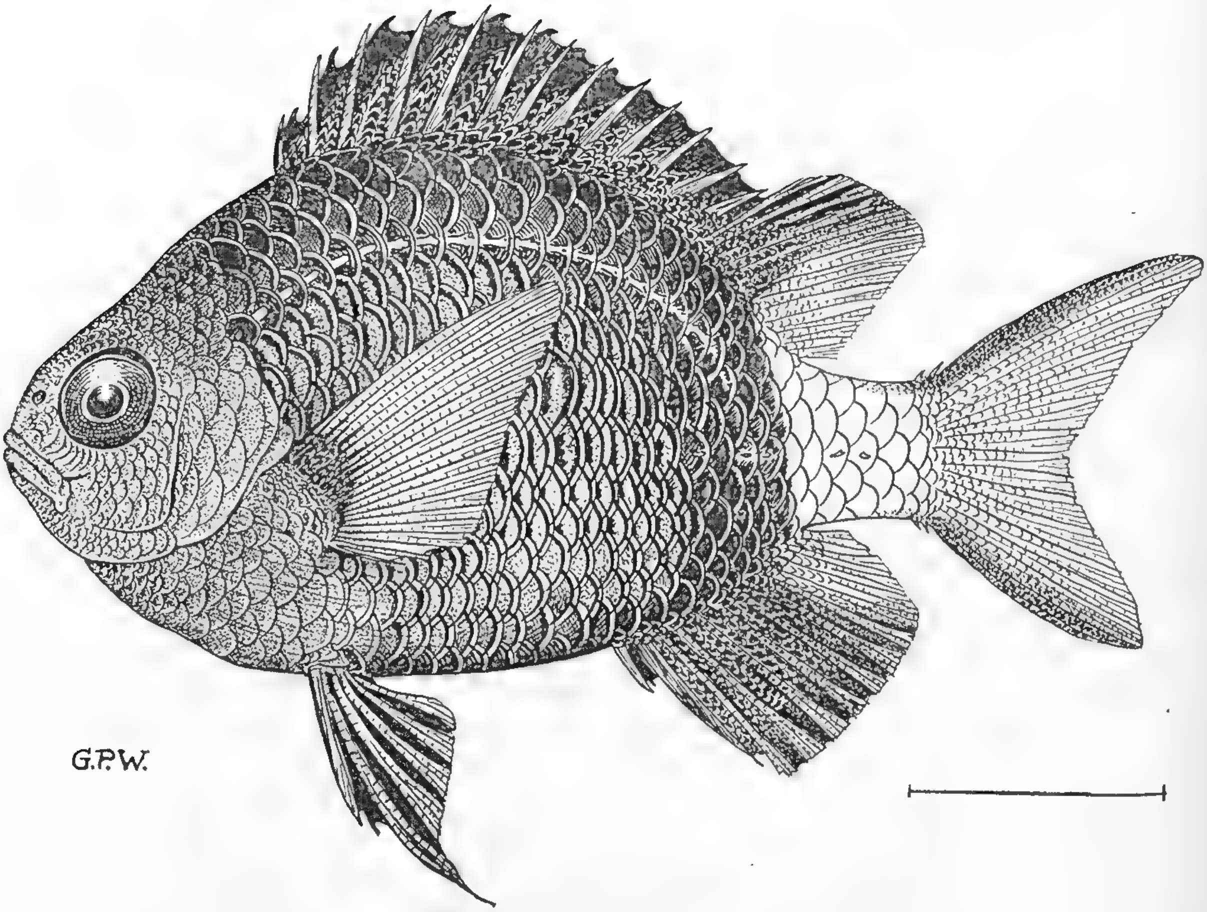


Figure 11.—Demoiselle, *Lepicephalochromis westalli*, sp. n. Holotype. Kenn Reef.

Genus **Lepicephalochromis** Fowler, 1943

Lepicephalochromis Fowler, 1943, *U.S. Nat. Mus. Bull.* 100 (14, part 2): 78.

Type-species, *Chromis cupreus* Fowler and Bean, 1923.

Lepicephalochromis westalli, sp. nov.

Fig. 11

D. xiii, 14; A. ii, 12; P. 19. L.lat. 19. Sc. 25. Tr. 3/1/9. Predorsal scales more than 20. Gill rakers 9 + 1 + 22 = 32 on first gill-arch.

Head (28 mm.) 3.1, depth (50) 1.7 in standard length (89). Eye, 10; snout, 6.5; interorbital, 12; maxillary, 7; length of pectoral fin, 34; of ventral, 29; second anal spine, 18; breadth of body, 19; base of spinous dorsal fin, 45, much longer than that of soft, 17; anal base, 22.5; longest dorsal spine, 13; height of second dorsal fin, 16; depth of caudal peduncle, 14 mm.

Eye large. Interorbital broadly convex. Snout scaly to before nostril. Preorbital scaly, entire; infraorbital exposed for very short distance before being covered with scales. All opercles entire. Single small opercular spine. Mouth reaching below front of eye. Lips normal. Teeth conic, spaced, uniserial; no second series of posterior teeth, otherwise as in *Lepicephalochromis cupreus*. Mandibular ramus elevated. Mandibular teeth not flared outwards. Tongue scoop-like. Four rows of cheek-scales with six to eight vertical rows. Some auxiliary scales on head and a few on forequarters of body. 9 + 1 + 22 external gill-rakers on first branchial arch. 15 internal gill-rakers.

Form deeply oval, compressed. Upper profile more convex than lower; predorsal trenchant. Body covered by ctenoid scales with several rows of apical denticles and up to about seven basal radii, without auxiliary scales. Small scales form sheaths to dorsal and anal fins. Two rows of scales between posterior tubed scales of l.lat. and back. Axillary scales at ventral fins small and rounded or long and pointed.

Base of spinous dorsal fin more than twice that of soft. Fin notched. Spinous dorsal membranes penicillate and incised. Fourth to sixth dorsal spines longest. First spine notably shorter than second and half the length of the third. First anal spine two-fifths of second. Second anal spine not nearly as long as head. Fin-lobes rather pointed; pectorals and ventrals long, the latter reaching first anal spine. Caudal forked.

Colour in alcohol, very dark brown, almost black on head, body and most of fins back to a line joining the anterior half of the second dorsal fin to the posterior rays of the anal fin. Behind this the posterior dorsal and anal rays and the intervening caudal peduncle and fin are cream with a light orange tinge except for the upper and lower caudal margins which are blackish. Eye blue, surrounded by a black orbit. Pectoral base black. No ocelli, bands, spots or notable markings.

Superficially the coloration resembles that of a *Pseudopomacentrus* in the same collection (regd. nos. IB.4908-9 and 4944-5) but that, of course, has serrated preoperculum.

Described and figured from the holotype of the species, a specimen 89 mm. in standard length or 4½ inches overall (Austr. Mus. regd. no. IB.4975) and a series of 23 paratypes (IB.4946-47 and 4976).

Locs.—Kenn Reef, Coral Sea; October 2, 1960 (Holotype and nine paratypes, IB.4976) and beyond the reef crest of Lihou Atoll, Coral Sea; September, 30, 1960 (14 paratypes, IB.4946-47); all collected by Dr. D. F. McMichael.

Named in honour of William Westall, A.R.A., F.L.S. (1781-1850), landscape painter aboard Matthew Flinders's *Investigator* voyage of 1801, who was wrecked aboard the *Porpoise* in August, 1803, and in whose painting of Wreck Reef we see some of the first representations of the coral fauna of the Great Barrier Reef system.

Distinguished from the only other species of the genus, originally named *Chromis cupreus* Fowler and Bean (1923, *Proc. U.S. Nat. Mus.* 63: 22, from "Fiji or Samoa"), by having uniserial teeth, more dorsal rays, fewer scales between anal fin and lateral line, and in its coloration: light caudal area margined above and below with darker on the caudal rays, black pectoral base and generally dark body in advance of a boundary joining the posterior portions of the anal and second dorsal fins.

Genus **Acanthochromis** Gill, 1863

Acanthochromis polyacanthus (Bleeker)

Dascyllus polyacanthus Bleeker, 1855, *Nat. Tijdschr. Ned. Ind.* 9: 492 & 503. Batjan, Indonesia.

Acanthochromis polyacanthus Fowler and Bean, 1928, *U.S. Nat. Mus. Bull* 100 (7): 27 (refs and synonymy).

D. xvii, 13 to 15; A. ii, 15. Head (28 mm.) 3.6, depth (58) nearly 1.8 in standard length (103). Profile deeply oval, nape gibbous; form compressed. Teeth conic. Preorbital and preoperculum finely serrated.

Fairly uniform blackish-brown. Centres of thoracic scales of adults with black streaks. Young with a milky-white curved band along l.lat. and a milky spot over caudal peduncle. One specimen (IB.4955) light brown with a bruise-like black area around the vent.

Four specimens, up to $5\frac{1}{2}$ inches long from off Lihou Reef, Coral Sea; September 30, 1960. (IB.4910-13) and one (IB.4955) from an offshore coral pool, Coringa Islet, about 250 miles east of Cairns in the Coral Sea, September 29, 1960.

Genus **Chromis** Cuvier, 1814

Subgenus **Chromis** Cuvier, 1814

Chromis kennensis, sp. nov.

Fig. 12

D. xiii, 11 (12); A. ii, 10; P. 20. L.lat. 17. Sc. 24. Tr. 3/1/9. Predorsal scales 25.

Head (22.5 mm.) 3.4, depth (36) 2.1 in standard length (78). Eye, 7 mm.; snout, 5; interorbital 8; maxillary, 7; postorbital 11; depth of caudal peduncle, 11; length of pectoral, 26; of ventral, 22; second anal spine, 12.5.

Profile broadly rounded. Form ovate, deepest near origins of dorsal and ventral fins. Snout scaly. Three rows of cheek-scales; six transverse rows of cheek-scales. Maxilla reaching below front of eye. Lips papillate. Teeth conic, not directed outward. Mandibular ramus gently sloping. Suborbital covered by scales, little free. All opercles entire. Twenty gill-rakers on lower limb of first gill-arch.

Body covered with ctenoid scales with about eight basal radii. Some auxiliary scales on or near head but not on body proper. One and a half rows of scales between l.lat. and back. Seven to ten lateral line pores along sides of caudal peduncle. Scales extend over bases of all fins except ventrals which have a lanceolate axillary scale.

Middle dorsal spines longer than the second one. Soft dorsal fin much higher than spinous one. Second anal spine shorter than soft rays. Fin-lobes all pointed. Anal base notably longer than soft dorsal base. Ventrals reaching beyond vent. Caudal forked, subequal to head.

General colour in alcohol mostly blackish but centres of lower scales grey, becoming silvery grey with brown margins on the belly, thorax and lower parts of head. Pectorals pale grey; other fins blackish—middle and posterior portions of caudal lighter grey. A large black mark over all pectoral base bordered behind by a lighter tone. Pectoral axil black. Eye silver. No notable bands or colour-marks. No blotch at end of soft dorsal. Tubes of l.lat. light greyish-brown.

Described and figured from the unique holotype (Austr. Mus. regd. no. IB.4973), 78 mm. in standard length or a little more than four inches overall.

Loc.—Kenn Reef, Coral Sea; October 2, 1960. Dr. D. F. McMichael.

Similar to *Chromis atripes* Fowler and Bean (1928, *U.S. Nat. Mus. Bull.* 100 (7): 43 pl. 2), from the Philippines and Indonesia, but distinguished from that, and from other species, by the large black blotch on pectoral base and other characters described above. The high number of predorsal scales, presence of l.lat. pores along caudal peduncle, and the scaly snout are useful recognition features.

Chromis atripes Fowler and Bean

Chromis atripes Fowler and Bean, 1928, *U.S. Nat. Mus. Bull.* 100 (7): 43, pl. 2. East Indies and Philippines.

D. xii, 13; A. ii, 13; P. i, 15. L.lat. 13 tubes plus a few rudimentary pores. Sc. 24. A median row of small pores along each side of caudal peduncle. Tr. 3/1/9. Predorsal sc. 17.

Head (15 mm.) 3.5; depth (34) 1.5 in standard length (53). Eye, 6 mm.; second anal spine, 8; upper caudal lobe about 21 mm.

Teeth conic, not flared outwards. Mandibulary ramus gently curved upwards.

Preorbital and suborbital covered with scales, little free. All opercles entire. Head very scaly, only eyes and mouth naked. A few auxiliary scales on head but not on body.

Anterior profile steep, gibbous predorsally. General form deep oval, strongly compressed. Dorsal spines compressed and thick, membranes pencilled and incised, the longest spines are about the fifth to eighth. Fin-lobes all pointed. Ventrals filiform, reaching anal spine. Caudal forked.

Colour in alcohol greyish-brown over most of head and body becoming dark brown peripherally: notably around the dorsum, over the dorsal fins (except posterior rays which are dirty whitish), over the ventral and anal fins (except posterior rays which are like those of the soft dorsal) and above and below the caudal peduncle and fin which thus has dark brown upper and lower margins and dull white median rays. A small dark brown blotch on pectoral base, followed by a light diffuse area before the greyish-brown of the main part of the pectoral fin. Eye dark blue, surrounded by a blackish ring which is surmounted by a milky-blue crescent around most of the "eyelid". A slight dusky brown smudge just behind preopercular margin. Body-scales not dark-edged.

Described from a specimen 53 mm. in standard length or 3 inches overall. (Austr. Mus. regd. no. IB.4978).

Loc.—Kenn Reef, Coral Sea; October 2, 1960. Dr. D. F. McMichael.

Chromis dimidiatus (Klunzinger)

Heliastes dimidiatus Klunzinger, *Verk. Zool. Bot. Ges. Wien* 21:529. Red Sea.

D. xii, 13; A. ii, 13; P. ii, 16. L.lat. 16. Sc. 23. Tr. 3/1/9. Predorsal scales 21.

Head (19 mm.) 3.4, depth (37) 1.7 in standard length (65). Eye 6 mm.; snout, 5; interorbital, 8; maxillary, 5.5; postorbital, 8.5; depth of caudal peduncle, 11; length of pectoral, 21; of ventral, 22; second anal spine, 8.

Form deeply oval, upper profile more convex than lower, greatest depth about half-way along standard length. Snout scaly. Four rows of cheek-scales. Maxilla not quite reaching below level of eye. Lips normal. Teeth conic, not directed outwards. Mandibular ramus gently curved upward. Suborbital covered by scales, free to below posterior part of eye. All opercles entire. About 20 gill-rakers on lower part of first branchial arch.

Body covered with ctenoid scales with about eight basal radii. No auxiliary scales but the scales over the lateral line and towards dorsal bases are diminished. About seven pores along sides of caudal peduncle. Scales extend over bases of all fins except ventral which have axillary scales.

Fourth dorsal spine longest. Soft dorsal much higher and, like the other fins, with rather pointed lobe. Second anal spine shorter than soft rays. Anal base much longer than soft dorsal base. Ventrals filiform, nearly reaching anal spine. Several spine-like procurrent caudal rays. Caudal strongly emarginate, slightly longer than head.

General colour in alcohol greyish-brown of varying tones with tendency towards broad, diffuse, darker bars, one occupying most of front, the other most of posterior part of body. Just before the hypural joint the colour changes abruptly to pale yellow or white on the caudal fin. All pectoral base and axil black. Eye blue. Orbital with black ring. A brown blotch over tip of operculum. Dorsal, anal and ventral fins very dark grey. Distal portions of dorsal and anal lobes whitish. Pectorals pale yellow behind the black base, then dirty whitish distally.

Described from a specimen 65 mm. in standard length or 3½ inches overall. Austr. Mus. regd. no. IB.4939.

Loc.—Beyond reef-crest, Lihou Atoll, Coral Sea; September, 1960. Dr. D. F. McMichael.

Distinguished by 21 predorsal scales, l.lat. pores on caudal peduncle, 13 anal rays, deep body, spine-like procurrent caudal rays, and in coloration.

Many smaller specimens from various Coral Sea localities.

Chromis dimidiatus, variation

A colour-variant which I at first thought might be quite distinct from other *Chromis dimidiatus* in the Coral Sea collection may be described as follows.

D. xii, 13; A. ii, 13; P. 18. L.lat. 14. Sc. 23. L.lat. pores on caudal peduncle rudimentary. Tr. 3/1/9. Predorsal scales about 17.

Head (19 mm.) 3.5, depth (37) 1.8 in standard length (67). Eye, 7 mm.; snout, 3.5; interorbital, 8; maxillary, 5; postorbital, 9; depth of caudal peduncle, 10; length of pectoral, 22; of ventral, 23; second anal spine, 6; longest upper caudal ray, 29; breadth of body, 13 mm.

Teeth conic, not flared outwards, outer enlarged row followed by some smaller ones. Mandibular ramus steep. General characters as in typical *dimidiatus*.

Form oval, upper profile more convex than lower, greatest depth about half-way along standard length. Snout scaly. Four rows of cheek-scales. Maxilla not quite reaching below level of eye. Lips normal. Teeth conic, not directed outwards. Mandibular ramus steeply curved upward. Suborbital covered by scales, little free. All opercles entire. About 9 + 21 gill-rakers on lower part of first branchial arch.

Body covered with ctenoid scales with about eight basal radii. No auxiliary scales but the scales over the lateral line and towards dorsal bases are diminished. About seven pores along sides of caudal peduncle. Scales extend over bases of all fins except ventrals which have axillary scales.

Middle dorsal spines longest. Soft dorsal much higher and, like other fins, with rather pointed lobe. Second anal spine shorter than soft rays. Anal base much longer than soft dorsal base. Ventrals filiform, reaching vent. Several spine-like procurrent caudal rays. Caudal strongly emarginate, longer than head.

General colour in alcohol brown, becoming lighter on the head, breast and tail. A vertical brown streak often present behind preopercular margin and another broader one at end of opercle. A large, conspicuous black blotch more than covers pectoral base and its axil. Pectoral greyish white. Caudal without dark edges above and below, usually dirty white but sometimes light grey or brown. Dorsal and anal fins dark brown, except posterior rays in each case which are light grey. Ventrals dark grey to blackish. Eye blue. Some scales of flanks dark-edged but not conspicuously so. One specimen (Austr. Mus. regd. no. IB.4863) has black interorbital. In all the others it is brownish in varying tones.

Described from a female (Aust. Mus. regd. no. IB.4938) specimen, 67 mm in standard length or $3\frac{3}{4}$ inches overall, also from 21 other specimens, from $2\frac{1}{2}$ to $3\frac{3}{4}$ inches overall, but the upper caudal lobe may be produced and threadlike to make a total of 4 inches in some.

Localities.—Beyond reef, Lihou Atoll, Coral Sea; September 30, 1960 (Aust. Mus. regd. nos. IB.4938, and 4940-41, three specimens). Frederick Reef, Coral Sea (IB.4863-65, three specimens). Kenn Reef, Coral Sea; October 2, 1960 (IB. 4990-91, 16 specimens). Obtained by Dr. D. F. McMichael.

Chromis fragoris, sp. nov.

Fig. 13

D. xii, 13; A. ii. 12; P. 16. L.lat. 15. Sc. 24. Tr. 3/1/8. Predorsal scales 19.

Head (19 mm.) 3.4, depth (42) 1.5 in standard length (65). Eye, 6.5 mm.; snout, 5; interorbital, 7.5; maxillary, 5; postorbital, 9.5; depth of caudal peduncle, 11; breadth of body, 14; length of pectoral, 22; of ventral, 23; second anal spine, 8; longest upper caudal ray, 40 mm.

Maxilla not reaching eye. Teeth conic, erect, in more than one row anteriorly. Mandibular ramus rising by about 45 degrees. Head scaly except eyes, middle of isthmus and around mouth. Suborbital free to half-way below eye. All opercles entire. Four rows of cheek-scales. Preorbital with one row of scales. About 23 gill-rakers on lower part of first branchial arch.

Form deeply oval and fairly compressed, upper profile more convex than lower, greatest depth about midway along standard length.

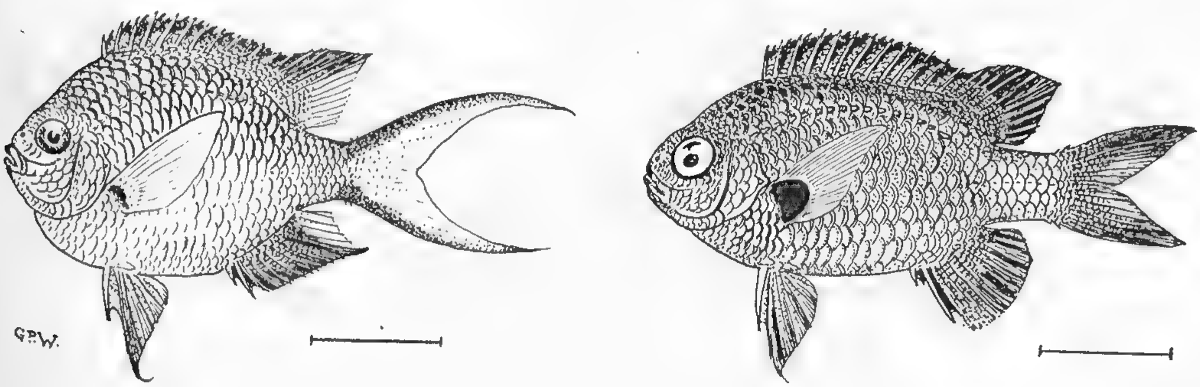


Figure 12—(right): Demoiselle, *Chromis kennensis*, sp. n. Kenn Reef.
Figure 13—(left): Demoiselle, *Chromis fragoris*, sp. n. Lihou Atoll.

Body covered with ctenoid scales with 6 to 10 basal radii. No auxiliary scales. Between l.lat. tubes and the back are $1\frac{1}{2}$ rows of scales. Some six to nine rudimentary l.lat. pores along side of caudal peduncle. Scales extend over bases of all fins except the ventrals which have axillary scales.

Spinous dorsal membranes incised and briefly pencilled, the fourth spine slightly the longest. Soft dorsal much higher than the spinous and, like all the other fins, pointed. Anal base longer than soft dorsal base. Ventrals reaching anal spines. Caudal forked with filamentous lobes. Two procurrent caudal spines above and below.

General colour in alcohol light reddish-brown, many of the scales with darker brown margins. Belly plain light orange-brown. A small brown blotch on most of upper portion of pectoral base, more on the rays than on the body. Pectoral axil pale. Paired fins mostly pale yellowish with some infuscation on ventrals. Dorsal and anal fins mostly blackish except for posterior rays and membranes which are white. Caudal dirty white, broadly margined above and below with dark smoky grey, almost black, these margins almost meeting at middle of caudal base. Eye blue with dark smoky orbital ring. Around lips dusky. No vertical dark bars behind preopercular or opercular edges.

Described and figured from the holotype, a specimen 65 mm. in standard length or $4\frac{1}{8}$ inches overall (Aust. Mus. regd. no. IB.4935) and 30 paratypes, $2\frac{3}{8}$ to $4\frac{1}{4}$ inches in total length (IB.4936-37 and 4942-43). Nearly a quarter of the total length of larger specimens is due to the elongation of the caudal rays.

Loc.—Beyond the reef-crest, Lihou Atoll, Coral Sea; September 30, 1960. Dr. D. F. McMichael. Obtained by explosives, hence Latin *fragoris*, of the explosion, alternatively, the thunder of the sea.

Similar to the variety of *dimidiatus* mentioned above (page 184), but differing in being deeper, having broad dark margins to caudal fin, a much smaller dark pectoral blotch and less contrast between the tones of the body and tail, longer snout, more produced caudal rays, and light-toned ventral fins.

Nearest *Chromis reticulatus* Fowler and Bean [1928, *Bull. U.S. Nat. Mus.* 100 (7): 40] from Borneo and Indonesia but differs in having deeper body (depth 1.5 instead of 2 or more in standard length), shorter maxillary, preorbital free, 12 dorsal spines and in being of smaller size.

Subgenus **Lepidochromis** Fowler and Bean, 1928

Lepidochromis Fowler and Bean, 1928, *U.S. Nat. Mus. Bull.* 100 (7): 58. Type-species, *Chromis lepidolepis* Bleeker.

Serrichromis Fowler, 1943, *U.S. Nat. Mus. Bull.* 100 (14): 77. Type-species, *Dascyllus pomacentroides* Kendall and Goldsborough.

Chromis (Lepidochromis) lepidolepis Bleeker

Chromis lepidolepis Bleeker, 1877, *Nat. Verh. Holl. Maatsch. Wetens.* (3) 2 (6): 163; *Atlas*, pl. 403, fig. 2. Timor.

D. xii, 11; A. ii, 11; P. 18. L.lat. 17. Sc. 25. Tr. 3/1/9. Predorsal scales 25.

Head (18 mm.) 3.2, depth (30) 1.9 in standard length (58). Eye, 6 mm.; second anal spine, 11 mm.

Teeth in several rows, the outer ones conic, spaced. External teeth of mandible erect, mandibular ramus elevated. Snout scaly to before nostrils. Preoperculum finely serrated, other opercles entire. Eye circular, without orbital papillae. Profile sloping from snout to swell below spinous dorsal so that upper profile more convex than lower. Form compressed. Body with ctenoid scales which extend over fin bases. Many auxiliary scales. Middle scales of caudal peduncle each with a lateral line pore.

Spinous dorsal membranes pencilled and incised. Lobes of fins pointed. Caudal fin strongly forked, upper lobe longer.

Colour in alcohol dark brownish grey, most scales with dark margins. No black or white bands or notable markings. Chin and breast silvery. Paired fins dull grey. Unpaired fins mostly blackish except for posterior anal rays and inner caudal rays which, with their membranes, are dull white. Pectoral axil whitish; a black dot over pectoral origin. Eye blue and silvery-green; a blackish line round the pale orbit. Mouth yellowish.

Described from a specimen 58 mm. in standard length or about 3 inches overall. Austr. Mus. regd. no. IB.4965.

Loc.—Kenn Reef, Coral Sea; October 2, 1960. Dr. D. F. McMichael.

Family **Coridae**

Genus **Anampses** Quoy and Gaimard, 1824

Anampses pterophthalmus Bleeker

Anampses pterophthalmus Bleeker, 1857, *Act. Soc. Sci. Indo-Neerl.* 2: 81. Amboina (*fide* Weber and Beaufort, 1911, *Fish. Indo-Austr. Archip.* 1: 65, q.v. for other refs.).

Id. Bleeker, 1862, *Atlas Ichth.* 1: 102, pl. 24, fig. 3.
Id. Macleay, 1883, *Proc. Linn. Soc. N.S. Wales* 8: 272.
Id. Jordan and Seale, 1906, *Bull. U.S. Bur. Fish* 25, 1905: 296.
Id. Weber, 1913, Siboga-Exped., Fische: 367.
Id. Fowler, 1928, *Mem. Bishop Mus.* 10: 331.
Id. Fowler and Bean, 1928, *Bull. U.S. Nat. Mus.* 100 (7): 225.
Id. Weber and Beaufort, 1940, *Fish. Indo-Austr. Archip.* 8: 98.
Id. Kamohara, 1955, *Bull. Biogeogr. Soc. Japan* 16-19: 312. fig. 1, and in his later papers.
Id. Randall, 1958, *J. Wash. Acad. Sci.* 48 (3): 107.
Id. Scott, 1959, *Trans. Roy. Soc. S. Austr.* 82: 85, fig. 5 (Shark's Bay, new record for Australia).
Id. Schultz, 1960, *U.S. Nat. Mus. Bull.* 202 (2): 220.
Id. Woodland and Slack-Smith, 1963, *Uni. Qld. Pap., Dept. Zool.* 2 (2): 44.

One (IB.6087), killed by rotenone at Gillett Cay, had the following characters:—

Head (52 mm.) 2.7, depth (50 mm.) 2.08 in standard length (143). Sc. 43 to hypural joint.

General colour in life dark chocolate brown. A milky stripe above upper lip to below eye, a second connects eyes over top of snout. Lips pink. Teeth white. Pupil black surrounded by brown, this surrounded by yellow, then blue on iris. Dorsal and anal fins brown, each with a dark blue ocellus, ringed by gold, posteriorly. Pectoral fin yellowish. Caudal brown with milky margin. Ventrals very dark brown.

Length $6\frac{3}{4}$ inches and thus about maximum size for the species. Australian Museum regd. no. IB.6087.

Gillett Cay, Swain Reefs, Queensland. 20.x.62.

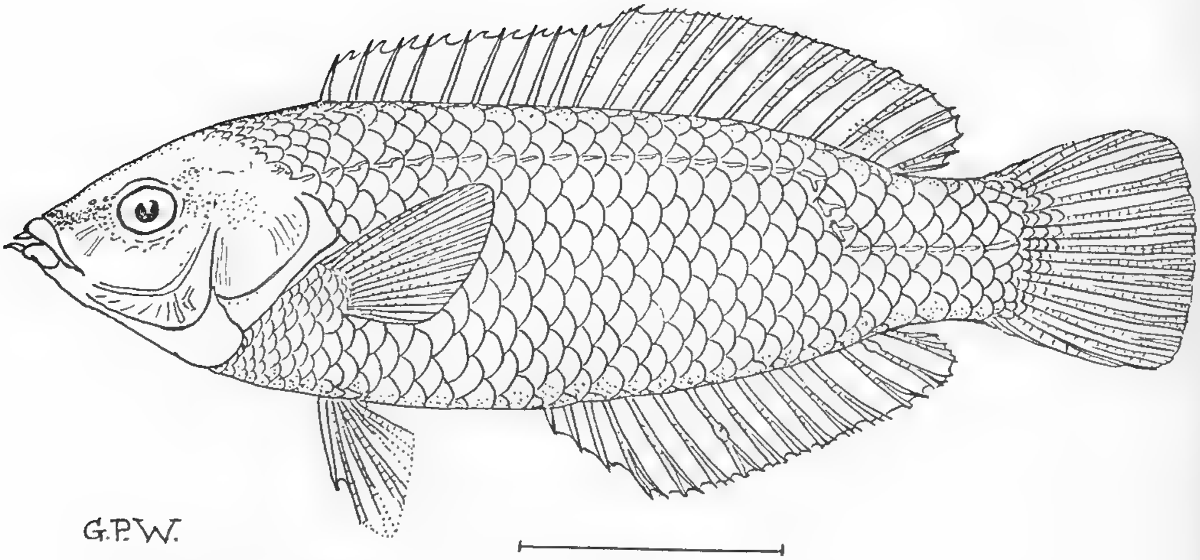


Figure 14—Wrasse, *Anampses elegans,* Ogilby. Holotype. Lord Howe Island.

Anampses elegans Ogilby

Fig. 14

Anampses elegans Ogilby, 1889, *Austr. Mus. Mem.* 2: 67. Lord Howe Island. Syntypes in Australian Museum, Sydney. *Id.* Waite, 1916, *Trans. R. Soc. S. Austr.* 40: 454 (listed from Lord Howe and Norfolk Islands).

Anampses variolatus Ogilby, 1889, *Austr. Mus. Mem.* 2: 67. Lord Howe Island. Type in Australian Museum. *Id.* Whitley, 1957, List Type-Specimens Fish. Austr. Mus. (roneo'd): 26, no. 432.

Of eight specimens labelled " (type) " by Ogilby, I select the largest as lectotype of *Anampses elegans* and figure it here (reg.. no. I.1932). The Australian Museum houses also the holotype of *A. variolatus* Ogilby (I.1938) which is conspecific. All the colour-markings described by Ogilby have long ago faded but there is still a trace of a dark blotch near the end of the soft dorsal fin in two of the syntypes. Since the Memoir in which *Anampses elegans* and its synonym *variolatus* were described is now rare I repeat here Ogilby's descriptions:—

Anampses elegans, sp. nov.

B. vi. D. 9/12. A. 3/12. V. 1/5. P. 12. C. 14. L.l. 26. L.tr. 4/10.

The length of the head is three and a half, the height of the body four in the total length. The diameter of the eye is four and two-thirds in the length of the head, two-thirds of that of the snout, and rather less than that of the flattened interorbital space. The mouth is small and oblique, and the maxilla does not extend to the vertical from the anterior nostril. The curve of the lateral line commences beneath the eighth dorsal ray.

Colors: Upper half of the head and back pale brown; sides and tail yellowish-grey; lower half of the head and thoracic region silvery; some blue dark-edged spots and lines on the upper surface of the head and behind the eye; scales between the lateral line and dorsal fin with numerous blue dots and transverse lines; below the lateral line seven longitudinal golden bands, as wide as the interspaces, which are ornamented by numbers of blue spots, which however fade gradually towards the abdominal region, which is immaculate. The dorsal and anal fins are golden with a very narrow dark border, the former with a basal and median row of pale-blue dark-edged spots, the latter spotless; the caudal fin is golden with its outer margin greyish; the pectorals and ventrals are grey, the base of the former with a broad golden band.

Mr. Saunders collected several specimens of this handsome *Anampses,* all of which measure between four and five inches in length, and were obtained fiom pools on the reefs. Register numbers I. 1932-1937.

Anampses variolatus, sp. nov.

B. vi. D. 9/12. A. 3/12. V. 1/5. P. 13. C. 14. L.l. 28. L.tr. 6/11.

Colors: Pale reddish-yellow with a broad brown band from the middle of the operculum through the eye to the anterior edge of the snout, where it joins the corresponding band on the opposite side; a curved band from the centre of the cheek to the angle of the preopercle; occiput brown: body with brown blotches, which sometimes coalesce to form semi-transverse bands, and are visible but indistinct on the dorsal fin; a broad silvery band from the mouth to the opercle, partly interrupted by the curved brown band, and continued as far as the caudal fin by means of large irregular blotches; above this is a much narrower and more indistinct band of similar blotches; the fins are pale yellow, with a small round black spot on the two penultimate rays of the dorsal and anal.

I have a single immature specimen only of this species, but the colors are so different from those ordinarily found in this genus that I am compelled to describe it as new. Register number, I.1938.

I am unable at present to synonymise Ogilby's species with any of the 28 or so nominal species which have been named. Due to variations in colour with growth or sex in these fishes, it is probable that the number of species may be drastically reduced. An alphabetical list of those so far named follows:—

Anampses (sensu lato) spp.

amboinensis Bleeker, 1857, *Act. Soc. Sci. Indo-Neerl.* 2: 80. Amboina, Indonesia.

caeruleopunctatus Ruppell, 1829, *Atlas zu Ruppell* (*Senckenb. Nat. Ges.*), Fische: 42, pl. 10, fig. 1. Tor, Red Sea.

chlorostigma Cuvier & Valenciennes, 1839, *Hist. Nat. Poiss.* 14: 9. *Ex* Ehrenberg MS. Red Sea.

chrysocephalus Randall, 1958, *J. Wash. Acad. Sci.* 48 (3): 100, fig. 3. Oahu, Hawaii.

cuvier Quoy and Gaimard, 1824, *Voy. Uranie, Zool*: 276, pl. 55, fig. 1. Mowi, Sandwich Islands.

diadematus Ruppell, 1835, *Neue Wirbelth. Abyssin., Fische*: 21, pl. 6, fig. 3. Red Sea.

dimidiatus Fowler and Bean, 1928, *Bull. U.S. Nat. Mus.* 100 (7): 225, errore pro *diadematus*. Red Sea.

elegans Ogilby, 1889, *Austr. Mus. Mem.* 2: 67. Lord Howe Island.

evermanni Jenkins, 1900, *Bull. U.S. Fish. Comm.* 19, 1899: 57, fig. 14. Honolulu.

fidjiensis Sauvage, 1880, *Bull. Soc. Philom. Paris* 7 (4): 224. Fiji.

geographicus Cuvier & Valenciennes, 1839, *Hist. Nat. Poiss.* 14: 10, pl. 389, " on ne connait pas le patrie ".

godeffroyi Gunther, 1881, *J. Mus. Godef.* 4 (15), Fische Sudsee 7: 252, pl. 140. Sandwich Islands.

ikedai Tanaka, 1908, *J. Coll. Sci. Imp. Tokyo* 23 (7): 32, pl. i, fig. 2. Japan.

lennardi Scott, 1959, *Trans. Roy. Soc. S. Austr.* 82: 86, fig. 6. Point Sampson, W. Australia.

lineolatus Bennett, 1836, *Proc. Zool. Soc. London* 3 (36): 208, Mauritius.

melanurus Bleeker, 1857, *Act. Soc. Sci. Indo-Neerl.* 2: 79. Amboina, Indonesia.

meleagrides Cuvier & Valenciennes, 1839, *Hist. Nat. Poiss.* 14: 12. Mauritius.

moniliger Cuvier, 1827, Planches de Seba 5: 6. Indonesia.

nagayoi Tanaka, 1908, *J. Coll. Sci. Imp. Tokyo* 23 (7): 34, pl. 1, fig. 3. Japan.

neoguinaicus Bleeker, 1878, *Arch. Neerl. Sci. Nat.* 13: 57, pl. Dutch New Guinea, now Irian.

pterophthalmus Bleeker, 1857, *Act. Soc. Sci. Indo-Neerl.* 2: 81. Amboina, Indonesia.

pulcher Regan, 1913, *Proc. Zool. Soc. London* 1913: 371, pl. 58, fig. 3 and pl. 59. Easter Is. and Tahiti.

rubrocaudatus Randall, 1958, *J. Wash. Acad. Sci.* 48 (3): 103, fig. 4. Oahu, Hawaii.
taeniatus Sauvage, 1891, *Hist. Nat. Madagascar, Poiss.*: 457. Mauritius.
tinkhami Fowler, 1946, *Proc. Acad. Nat. Sci. Philad.* 98: 162, fig. 30. Riu Kiu Islands.
twistii Bleeker, 1856, *Act. Soc. Sci. Indo-Neerl.* 1: 56. Amboina, Indonesia.
variolatus Ogilby, 1889, *Austr. Mus. Mem.* 2: 67. Lord Howe Is.
viridis Cuvier & Valenciennes, 1839, *Hist. Nat. Poiss.* 14: 13. Mauritius.

Family **Caracanthidae**

Genus **Caracanthus** Kroyer, 1844

Micropus Gray 1831, *Zool. Misc.* 20. Type-species *M. maculatus* Gray, from "The Pacific Sea". Preoccupied by *Micropus* Meyer and Wolf, 1810, Taschenb. d. Vogel: 280, a genus of birds. Not *Micropus* Kner, 1868, another genus of fishes.

Caracanthus Kroyer, 1844, *Nat. Tidskr.* [2] 1 (3): 264. Type-species, *C. typicus* Kroyer from Oahu, Hawaiian Islands. *Id.* Troschel, 1847, *Rept. Zool.* 1844: 555.

Amphiprionichthys Bleeker, 1855, *Nat. Tijdschr. Ned. Ind.* 8: 170. Type-species, *A. apistus* Bleeker from Cocos Islands.

Centropus Kner, 1860, *Sitzungsber. Akad. Wiss. Wien* 39: 531. Type-species, *C. staurophorus* Kner from ? (not seen). Preoccupied by *Centropus* Illiger, 1811, Prodromus: 205, a genus of birds.

Crossoderma Guichenot, 1869, *Mem. Nouv. Arch. Mus. Paris* 5: 194. Type-species, *C. madagascariense* Guichenot from Madagascar.

Trachycephalus De Vis, 1884, *Proc. Linn. Soc. N.S. Wales* 8: 455. Type-species, *T. bankiensis* De Vis from Banks Group, South Pacific (Syntypes in Austr. Mus.). Four times preoccupied (in batrachians, fishes and reptiles).

Caracanthus maculatus (Gray)

Micropus maculatus Gray, 1831, *Zool. Misc.*: 20. "Pacific sea" [= Hao, Paumotus].
Caracanthus maculatus Fowler, 1900, *Proc. Acad. Nat. Sci. Philad.* 1900: 515, pl. 20, fig. 5.

Id. Jordan and Evermann, 1905, *Bull. U.S. Fish. Comm.* 23: 453, fig. 198.
Id. Jordan and Seale, 1906, *Bull. U.S. Fish. Comm.* 25, 1905: 380.
Id. Fowler, 1928, *Mem. Bishop Mus.* 10: 299 (q.v. for bibliography).
Id. Herre, 1936, *Field Mus. Zool. Ser.* 21: 266.
Id. Pietschmann, 1938, *Bull. Bishop Mus.* 156: 31, pl. 10, text-fig. 7.
Id. Kamohara, 1955, *Rept. Usa Mar. Biol. Stat.* 2 (2): 1, fig. 1.
Id. Smith, 1958, *Ic. Bull. Rhodes Univ.* 12: 172, pl. 8, fig. G.

Two dark brown specimens (regd. no. IB.6064-5) from Capre Cay, Swain Reefs: 23.x.62. Caught at the same time as *Gobiodon verticalis*, with which it may have some special association as the two genera are several times recorded as having been taken together. The habits of the related *C. unipinnis* have been discussed by Hiatt and Strasburg, 1960, *Ecol. Monogr.* 30: 94.

An old specimen (IA.3669) in the Australian Museum from Somerset, Cape York, Queensland; coll. B. L. Jardine, 1914.

New record for Australia.

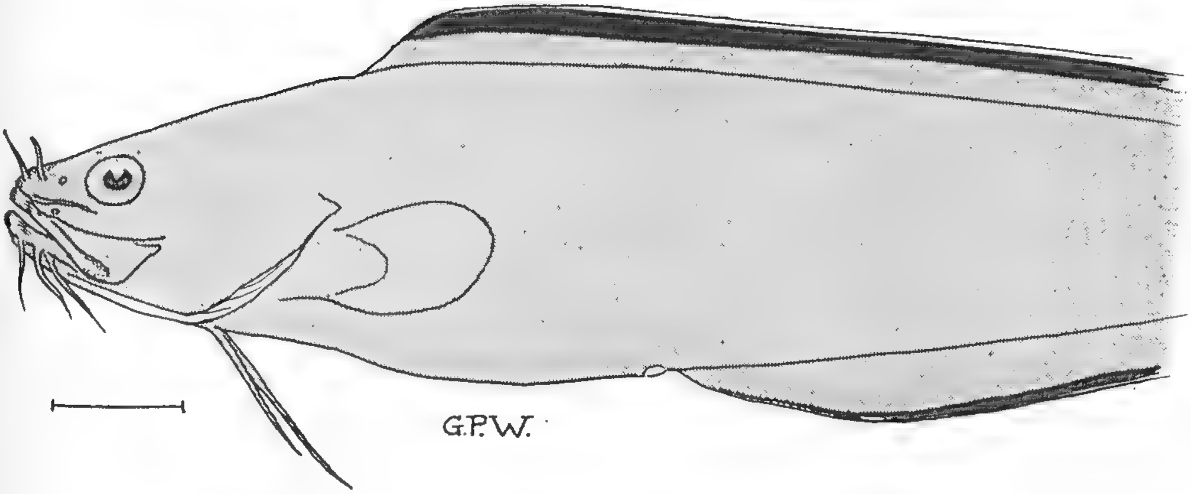


Figure 15—Beardie, *Brotula multibarbata.* Lord Howe Island.

Family **Brotulidae**

Genus **Brotula** Cuvier, 1829

Brotula multibarbata Temminck and Schlegel

Fig. 15

Brotula multibarbata Temminck and Schlegel, 1846, Fauna Japonica (Pisces); 251, pl. 111, fig. 2. Simabara Bay, Japan. *Id.* Hubbs, 1944, Copeia 1944 (3): 170 (q.v. for bibliography, synonymy, etc.). *Id.* Johnson, 1945, Copeia 1945: 55, *Id.* Gosline, 1953, Copeia 1953 (4): 216, figs. 1*a*, 2*a*, and 5*a*. *Id.* Kamohara, 1954, *Rept. Usa Mar. Biol. Stat.* 1 (2): 2, fig. 1. *Id.* Schultz and others, 1960, *U.S. Nat. Mus. Bull.* 202: 383.

Head (64 mm.) 5.3, depth (61) 5.5 in standard length (340). Eye, 12 mm; snout, 16; fleshy interorbital, 8.5; postorbital, 38; suborbital, 7; preorbital, 11; maxillary length, 33; its expansion, 12; depth of head, 52; its width, 38; predorsal length, 72; snout to vent, 130; to base of ventral fin, 49; ventral origin to vent, 88; length of ventral fin, 42 mm.

Head rather conic, jaws subequal anteriorly. Maxilla extending beyond the eye. Anterior nostril small, with barbel; posterior one open oval, nearer eye than end of snout. Eyes oval, interorbital flat; width of pupil less than half eye-diameter. Left narial barbel, 7 mm.; right, 11; preorbital barbel, 13; rostral barbel, 11; anterior mental barbel, 15; second mental barbel, 12; third, 18. Bands of small, curved, conic teeth around jaws, but with a gap at each symphysis, the upper gap the wider. Similar teeth in broad V-patch on vomer and curved bands on palatines. About 4 rows of teeth at sides of jaw and about 9 anteriorly. No enlarged teeth but the largest are atop the cushions of teeth each side of the lower symphysis. Tongue free, lanceolate. Head scaly, except on eyes, lips, and branchiostegal apparatus. Gill-membranes united across narrow isthmus. Gill-opening wide, reaching to below middle of eye. No pseudobranchiae. Preoperculum covered by skin and scales; no evident spine. First branchial arch with four, cushion-like, spinose, rather rudimentary gill-rakers on upper portion, a long (5 mm.) raker at the angle with its inner surface and distal extremity spinose, followed by two similar, shorter ones on the lower portion, with a roughened area between them and then 10 cushion-shaped rudiments below. Longest gill-fringes equal to longest raker.

Body deeper than wide, rounded anteriorly, strongly compressed posteriorly, originally covered with detachable scales which extend on to all fin-bases except ventrals. The scales are small, very numerous and counts cannot be made with certainty but there are some 40 between dorsal origin and level of narial barbels, a greater number on the linea transversalis and about 140 rows of scales between head and caudal base. Scales are imbricate, irregular or oval, cycloid, radially sculptured with lines joining the ridges rather like spider-web, nucleus eccentric, base deeply embedded in pocket. About three (yearly?) annuli and numerous basal radii. No lateral line now visible, perhaps destroyed. Vent large, without genital cage, situated slightly in advance of anal fin.

No fin-spines. The dorsal fin originates behind head and continues to join the much reduced and very acutely pointed caudal fin. Anal fin similar to dorsal, originating in anterior half of fish. Pectorals short and rounded, without free rays. Ventrals narrow, filiform, originating on isthmus below preoperculum, their bases close together, inner ray longer than outer one, neither bifid. Most fins covered with fatty skin making fin-counts difficult, so that the following are only very approximate: *D. circa* 110; A. 70 or more (some spurious rays developed between the true rays); P. 25 ?; V. 2; *C. circa* 6.

General colour in alcohol, white-skinned with the scales and edges of scale-pockets light brown. Lips and barbels greyish to brown. Eye blue, surrounded by dark grey orbital rim. Ventral fins light brownish-white. Other fins similar in colour to adjacent portions of body. Dorsal, anal and caudal fins broadly margined with black, the tips of some rays white. Pectoral base and axilla the same colour as the body. Inside of mouth and gill-chambers white. Vent dull white almost ringed with thin grey curved line. Premaxilla with dusky grey upper edge. Gill-arches pink. Vertex of head rusty red.

Described and figured from a specimen about 340 mm. in standard length and 365 mm. or $14\frac{1}{4}$ inches in overall length. Australian Museum registered no. IB.5833.

Loc.—Lord Howe Island, about July, 1962. Presented by Miss Julie Booth. Washed ashore after storm.

New record for Lord Howe Island.

Family **Clinidae**

Genus **Norfolkia** Fowler, 1953

Norfolkia Fowler, 1953, *Trans. Roy. Soc. N. Zeal.* 81: 262. Orthotype, *N. laird* Fowler = *Gillias squamiceps* McCulloch and Waite, 1916, *Trans. Roy. Soc. S. Austr.* 40: 449, pl. 41, fig. 1, from Lord Howe and Norfolk Islands.

Norfolkia thomasi, sp. nov.

Similar in most respects to *N. squamiceps* as described and figured in the reference cited above and agreeing with the type-specimens and others in the Australian Museum from Norfolk Island, Lord Howe Island and Queensland (Heron Island, Masthead Island and Swain Reefs), but consistently differing in having the cheeks and the lower parts of the opercula scaleless and in having only 13 instead of 21 or more tubes along the lateral line, the upper part of which ceases below the eleventh spine in the second dorsal fin, instead of below the second dorsal interspace.

The coloration and proportions are as in *squamiceps*, but the formulae are: D. iv/xiv-xv/ 11; A. i, 20-21; P. 9 branched + 6 simple; V. 2. L.lat. 13 plus a lower row of notched scales. Sc. 31-32. Tr. 2/1/7-8. The chest and pectoral base are scaly.

Described from the holotype (Austr. Mus. regd. no. IB.4040), the largest of three specimens 44, 46 and 47 mm. in total length, the other two (IB.4021) being paratypes, all from Heron Island. Another paratype (IB. 6245) from Gillett Cay, Swain Reefs.

Loc.—Heron Island, Queensland, 1957. Collected and presented by Mr. R. Slack-Smith whose field numbers for the specimens were H. 28 and H. 99. Seven specimens of true *squamiceps* (nos. H. 26 and J. 74) were taken at the same place.

The new species is named after Mr. Leonard Rees Thomas, organizer of the Australian Museum 1962 Swain Reefs Expedition.

Key to Australian *Norfolkia* spp.

A. Three spines in first dorsal fin.

B. 14 to 16 spines in second dorsal fin. 21 or more anal rays. L.lat. extends to below 4th to 9th dorsal ray . . . *clarkii* (syn. *macleayana*).

BB. 13 spines in second dorsal fin. 20 or fewer anal rays. L.lat. extends to near end of third dorsal fin. .... *striaticeps*.

AA. Four spines in first dorsal fin.

C. Scales on opercles and cheeks below. 21 to 24 tubes along l.lat. *squamiceps* (syn. *lairdi*).

CC. Cheeks naked below and opercle more or less naked below. 13 tubes along l.lat. .... *thomasi*, nov.

Norfolkia squamiceps (McCulloch and Waite)

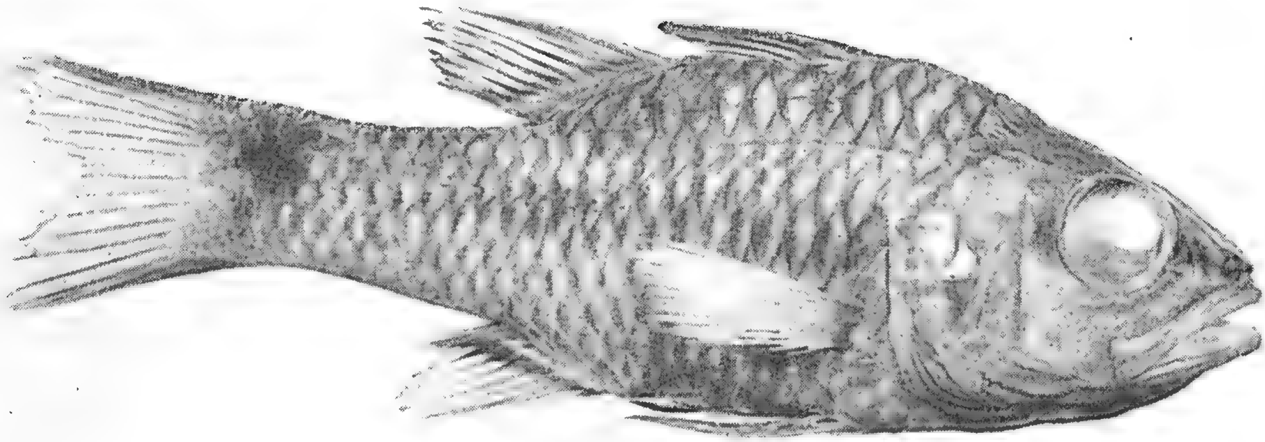
Diagnosis—an Australian blenny with three dorsal fins, top and sides of head almost entirely scaly, also belly, breast and pectoral base, lower part of head naked.

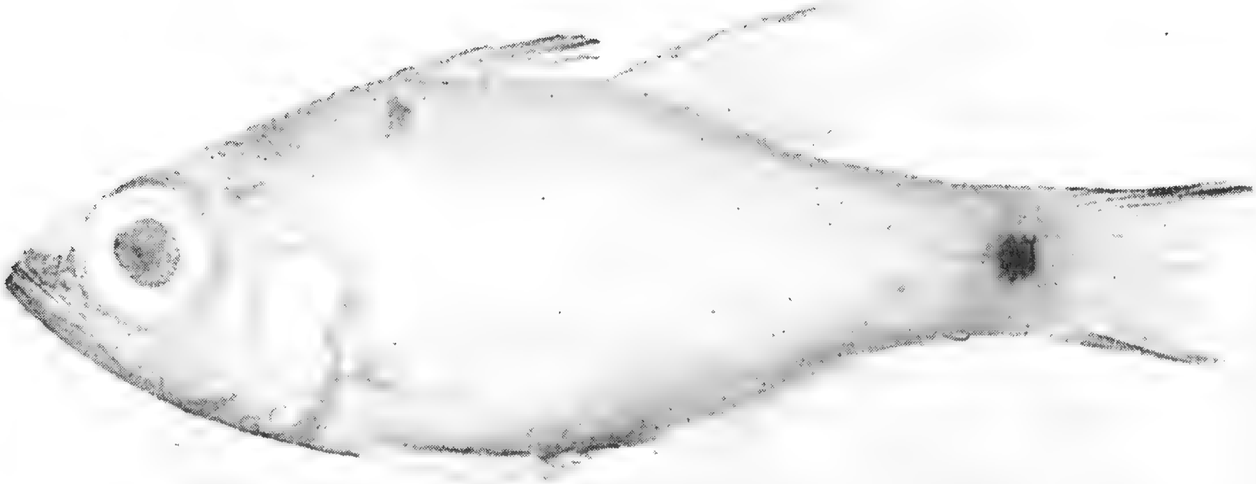
D. iv/14, 9 (10) = 27; A. 20; P. 16; V. 2; C. 12 long rays. Sc. 30. Tubes on first 20. Tr. 4/1/8 or 5 on caudal peduncle. Pred. sc. 5 to interorbital. Supra-orbital rugose. Long tentacle at nostril.

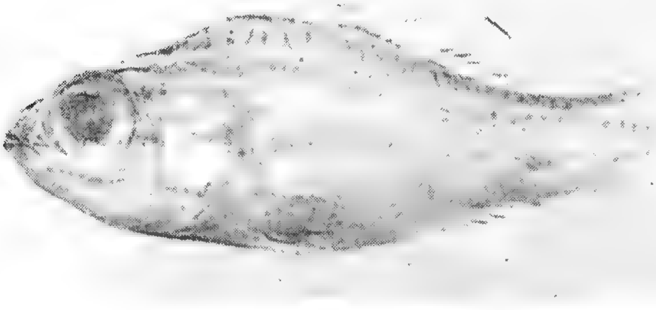
General colour dull pearly white, plain on ventral surface but densely infuscated with brownish-grey elsewhere. The dark markings are irregular but tend to form cross-bars, (1) below eye, (2) just behind and below eye and (3) eight or more descending from back down the flanks. Fins mostly densely spotted with brownish-grey, but the anal is fairly uniform blackish along its centre and white proximally and distally. Ventrals white. Eye blue, surmounted by a black tentacle.

Total length 2 inches.

Australian Museum regd. no. IB.6161. Gillett Cay, Swain Reefs, Queensland, October 1962.







THE ARCHAEOLOGY OF THE CAPERTEE VALLEY, NEW SOUTH WALES

By FREDERICK D. McCARTHY

Australian Museum

Plates 11-24 Text Figs. 1-6 Manuscript received 1-2-63

In 1951 Mr. J. Norcross reported to the Australian Museum several rock shelters containing stencils that he had inspected in the Capertee Valley, near Glen Davis. His attention was drawn to them by local residents, particularly W. Ferguson (store-keeper), to whom they had been known for some 50 years. At my request, Mr. Norcross dug a test hole in the floor of two sites, 1 and 3 in this paper, which produced *Bondi* points and waste flakes. In 1954 Mr. J. Bland, of Sunny Corner, further examined the sites at my request, and test holes dug by him yielded Bondaian culture implements and patinated yellow flakes not known elsewhere. Excavations of the sites were undertaken in 1958.

The following were members of the excavating parties during university vacations for periods of from 7 to 10 days:—

December, 1958: Professor N. W. G. Macintosh, Department of Anatomy, University of Sydney; Mr. D. Currie, of Imperial Chemical Industries, Sydney; Mr. J. Bland, farmer, Sunny Corner; Mr. V. Rose, Fruit Inspector, Bathurst; Mr. P. Gresser, retired, Bathurst; and Mr. W. Coombes, medical student, University of Sydney.

December, 1959: Messrs. J. Bland and D. Currie and the following members of the Sydney University Rover Scout Crew: Messrs. G. Ford, R. Jamieson and P. Sinclair.

May, 1960: Messrs. J. Bland and D. Currie and the following members of the Sydney University Rover Scout Crew: Messrs. R. J. Baker, G. Ford, R. Higgins, R. Jamieson, A. McHugh, P. Sinclair, R. Sutton and W. Warne; Messrs. B. Shanahan and A. P. Walker, Arts Students at the University of Sydney, and E. D. McKenzie, Ph.D., student in Chemistry at the University of New South Wales.

May, 1961: Messrs. J. Bland, D. Currie, R. French and J. Paterson (the latter two of the C.S.I.R.O.) and the following members of the Sydney University Rover Scout Crew: Messrs. A. McHugh, R. Lucas and R. Jamieson.

Mr. P. H. Walker, Research Officer, Soils Division, C.S.I.R.O., was present during several of these periods and participated in the excavation during one of them.

The author organized and led each of the four parties. He is extremely grateful to all of the above, and particularly the Sydney University Rover Scout Crew, for their generous assistance in this arduous series of excavations.

The Capertee River rises in the Triassic sandstone plateau which forms the main topographical feature of the countryside. In the Glen Davis area the river is joined by many creeks, among which Running Stream or Coorongooba, Cook's or Coco, and Umbiella are the most important. The main valley is up to 10 miles wide, and is a mixture of alluvial flats and low hills now used mainly as cattle pastures. The Capertee flows eastward through a deep and narrow gorge, in which sites 1 to 4 are situated, which it has cut through the Hawkesbury and Narrabeen sandstones. The gorge is over 1,000 feet high, and at the base of it Permian Lithgow coal measures, in which cherts are present, are occasionally exposed.

The environment is fertile, with an average rainfall of 20 in., but is subject to periodic dry spells varying in length from one summer to several years, when bushfires are common in this type of country. The summer temperatures rise to over the century and the winter temperature falls to the low 30's. The countryside is covered by open woodland eucalyptus forest, with comparatively dense epiphytic undergrowth. It could be described as an ideal environment for a hunting and gathering people of semi-nomadic habit. Game in the area includes all of the major kinds of Australian mammals—grey kangaroos, swamp and rock wallabies, ring-tailed and brush-tailed possums, wombats, echidnas, koalas, platypuses, bandicoots, phalangers, and various small rodents; emus (in the more open country), ducks, scrub turkeys, pigeons, herons and many other species of birds; goannas and a variety of lizards and snakes; eels, perch, crayfish and mussels in the river; bees, moths and other insects. Several species of yams, the seeds of the kurrajong, *macrozamia*, *acacias*, *pinus* and other plants, and various leaves, berries and fruits added the vegetable element to a well-balanced diet. The methods of hunting included the use of the spear, club, boomerang, burning-off and group ambushes to kill the bigger animals; others were dug and burnt out of trees and holes in the ground, and bird nets were in use. The game would no doubt become very wary and difficult to kill after a few weeks of hunting by the Aborigines in these confined gorges and valleys, and for this reason the families and local groups either used a number of shelters during the year, or spread their hunting over a wide area in the valley.

No major geological or physiographical changes took place during the occupation of the area by the Aborigines. It is obvious that in a period of thousands of years the river would make deeper inroads into its bed, and many falls of rock would take place along the cliffs, otherwise the building up and consolidation of the soil mantle, and the growth of vegetation after forest fires, are the only features worth noting. There is no evidence, as Mr. Walker's report on the soil and landscape history of the area makes clear, to indicate that there has been any marked change in climate during the period of occupation of the sites.

All of the shelters examined, of a size and kind suitable for habitation, in the Capertee Valley have been inhabited by man, but the distribution and size of the local groups and their territories are unknown. The area is in the north-eastern corner of the territory of the Wiradjuri tribe, near its border with the Darkinung tribe. The Wiradjuri belong to the No (Wira) group of tribes, with sections and matrilineal moieties, and with totemic clans each of which seems to have consisted of quick and slow blooded divisions; personal and sex totems existed (Brown, 1931, 59-61).

STRATIFICATION

When the first excavation of sections 1 to 4 in site 1 had been taken down to the bottom of the deposit by six-inch layers, it was found that from the bottom of the dark ashy layer at the top downwards, it was impossible for an archaeologist to distinguish separate depositional strata. For this reason the deposits were excavated in layers from 3 to 6 in. thick. Mr. P. H. Walker, M.Sc., Division of Soil Science, Commonwealth Scientific and Industrial Research Organisation, kindly accepted my invitation to make an analysis of the deposits in sites 1 and 3, which is published separately (1964).

The cave deposits are derived from the fretting of the walls and from aeolian deposition, and are not due to river sedimentation.

A hearth in the form of a basin of ashy sand several feet in diameter and 6 in. thick occurred in section 4 of site 1. Ash from a fireplace was noted among boulders in a densely packed layer at a depth of 36 in. in the western portion of site 3. In sections 6 to 11 a large pit of grey ashy soil, which lightened in colour toward the bottom, apparently constituted a traditional and long used fireplace during the occupation, as it extended from the surface to a depth of 54 in. and was clearly demarcated from the buff-coloured sandy soil surrounding it. In layer 1, section 6 of site 3, a mass of *Macrozamia* shells and kernels, a few mussel shells, burnt wallaby bones, and large lumps of charcoal was uncovered in a hearth 6 in. thick. Macrozamia appeared to be an important item of food, the palms growing in big patches in various places.

Mr. R. O. Chalmers, A.S.T.C., Curator of Mineralogy, Australian Museum, identified four different chemical processes, due to various solutions from the sandstone filtering through the deposits, affecting the surfaces of the cores, implements and flakes. Manganese stained them with a patchy black pattern tending to a dendritic condition on some pieces. Iron solution stained a high proportion of the pieces from a very pale yellow or orange to a mottled orange, and on some to a very deep umber patination. The pieces in the hearths or ashy areas are stained grey from the charcoal in solution. Finally, calcium carbonate cemented grit, quartz and stone fragments to one surface of many implements and flakes. This encrustation varies from a thin surface discolouration to a layer up to $\frac{1}{4}$ in. think. It is present from layers 2 to the bottom of the deposits in sites 1 and 3. The manganese and iron staining are both present from the top to the bottom layers.

It is important to note that the inhabitants did not acquire the various diagnostic specialized types of implements at the one time, but as a succession of new ideas. It will be noted that in site 1 *elouera* did not occur below 18 in., fabricators and prismatic cores below 24 in., *Bondi* points and geometrics below 30 in., that saws were not found above 30 in., and a few burins were found to a depth of 54 in. In site 3, however, ground edge axes appeared between 18 and 24 in., while *eloeura*, *Bondi* points, geometrics and burins were not found below 30 in., prismatic cores occurred as deep as 48 in., and fabricators as deep as 54 in. The few *Bondi* points and geometrics found in the Capertian portion of the deposit in site 1 need not be considered here as they apparently slipped down in the course of time through the faunal cavities. The change in both deposits to the second soil system R is within 6 in. of the bottom level of the *Bondi* points and geometrics, the correlation being so close that it might be accepted as the Bondaian stratification. From 24 in. down to the bottom of the true implement zone at 72 in. in site 1, and from 36 in. to this point at 84 in. in site 3, might be accepted as the Capertian stratification. The basal soil system T contained practically no implements in either site.

TABLE 1

Site 1

	Implements	Depth	Soil
Bondaian	Bottom levels of:— Ground edge axe	18 in.	Loose dark-grey ashy sand, rich in bone fragments with occasional mussel shells, of variable thickness.
Bondaian	*Elouera*, *Bondi* points, geometrics and burins.	30 in.	
		36 in.	Loose reddish sand, slight white mottling, thin clay band at back of shelter.
Capertian	Prismatic cores.	48 in.	
Capertian	Fabricators.	60 in.	
		76 in.	Abrupt change to basal red and yellowish mottled cemented sandy loam, with network of faunal channels ½ in. dr.
Capertian	Bottom of true implement zone.	84 in.	Bouldery talus zone.
	A few scattered flakes and implements.		

TABLE 2

Site 3

West section		Implements	Depth	*East section*
Dark-grey loose ashy sand rich in bone fragments, some mussel shells.	Bondaian	Bottom levels of	15 in.	Very loose ashy sand rich in bone fragments, occasional mussel shells.
	Bondaian	*Elouera*	18 in.	
	Bondaian	Fabricators and prismatic cores.	24 in.	Light-brown, very fragile sand with frequent faunal cavities ½ in. in diameter.
Loose pale-brown sand, thin horizontal bands of red clay which become thicker as the depth increases.	Bondaian	*Bondi* points and geometrics.	30 in.	
			36 in.	Stony layer of densely packed sub-rounded sandstone fragments with reddish clay bands.
	Capertian	Bottom of true implement zone.	72 in.	
Basal, weakly cemented red sandy loam.	Capertian	A few scattered implements and flakes.		Soil passes abruptly into the basal boundary zone of red, weakly cemented, clayey sand.

DISCUSSION

The whole investigation indicates that the development of stone working was a progressive process over a long period while the shelter deposits were built up steadily. Should this be so, the addition of these diagnostic traits to the culture of these people can be explained by differential diffusion in time. This conclusion is supported by the fact that one *tula* and one *Burren* adze slugs were found in the top 18 in. of sites 1 and 4. The diffusion of the knapped adze worked back to a slug in eastern New South Wales was thus a recent extension of its distribution compared to its entrenchment on the lower Murray River for between 6,000 and 7,000 years (Tindale, 1957, Mulvaney, 1960b). This explanation also accounts for the appearance of the *Bondi* points in the top layer of Fromm's Landing rock shelter on the Lower Murray (Mulvaney, 1960b) an area to which, apparently, the *Bondi* point extended its distribution in comparatively recent times. We must not ignore the important fact that four diagnostic traits, the *Bondi* point, geometrics, burins and *elouera*, all occurred to a depth of 30 in. in site 3 but not below that depth, and it could be argued that the addition of so many traits at one time was due to the arrival of a new wave of people. In view of the facts, however, that a basic flake and blade industry runs right through the Capertian and Bondaian periods, that the ground edge was the last important trait to reach the area, and that the building up of the deposits was a steady and apparently undisturbed process above the basal soil, it would appear that the change took place in the culture, and not in the people. The evidence is thus insufficient to advocate a new wave of people occupying the site at the beginning of the Bondaian phase.

Comparison With Noola Site

The findings at Noola (Tindale, 1962) tell much the same story as sites 1 and 3 in the Capertee gorge. In the latter sites there was no definite sterile band 12 in. thick, indicating virtual absence of visits, followed very suddenly by dense accumulations of occupational debris of the succeeding microlith-using people as at Noola, and the only evidence that these sites were occupied intermittently during the Capertian phase is that layer 6, 31-36 in. in site 1, yielded few implements.

Tindale (1962) assigned the lower culture phase at Noola to the Tartangan, despite the fact that it does not contain any *tula* or slugs, and its large flakes are completely different to those at the type site of Tartanga on the lower Murray. I have examined the specimens from the latter site, and pointed out (confirmed by Mulvaney, 1961) that the only diagnostic implement among them is the *Burren* adze slug, of which there are six. These slugs do not occur in the Capertian, as I have named the lower phase in this area (McCarthy in Mulvaney, 1960a; McCarthy, 1959-62, 1962 a-b), and saws, which are typical of the Capertian, are unknown in the true Tartangan. Tindale (*op. cit.*) in turn assigned the upper phase at Noola to the Mudukian, a term already supplanted by Pirrian (Mulvaney, 1961, 1962) as a result of his Fromm's Landing excavation. The only link between the Bondaian, as I have named the upper phase (McCarthy in Mulvaney, 1960 a-b; 1962 a-b) and the Pirrian lies in the geometric microliths, but the remainder of the diagnostic implements differ so much that Tindale's attempt to merge the phase into his lower Murray sequence must be rejected. There is no evidence to demonstrate that a hiatus of time involving the whole of the Pirrian phase of the lower Murray Tula culture (McCarthy, 1962a), from 3756 ± 85 to 4850 ± 100 years B.P. (Mulvaney, 1960b), during which there was no occupation of the sites, took place in the Capertee sites that I have excavated. I have pointed out repeatedly since 1949 that the Bondaian assemblage, except for the geometrics, is completely different to that of the Mudukian at the type site, and Mulvaney (1961) has supported this claim.

I believe that two culture traditions are involved, the one the inland tradition typified by worn-out slugs that I have named the Tula culture (1962 a-b), with an early (Tartangan), middle (Pirrian) and late (Murundian) phases, the other the eastern culture with an early (Capertian), middle (Bondaian) and late (Eloueran) phases. Sites where these overlap may produce various aspects of one tradition or culture in reverse order to that of another site, depending upon the time of diffusion of each diagnostic trait to the particular site. It is essential that, in the present state of our limited knowledge of Australian prehistory, we restrict our nomenclature of cultures and their various phases to the areas or regions in which they are excavated or found on surface sites, and not, as Tindale (1957) is attempting, to relate the whole of our prehistoric industries to his excavation of over 30 years ago on the lower Murray River (Hale and Tindale, 1930).

Two other statements made by Tindale (1962) in reference to the Noola site may be questioned. One was that, " consonant with the absence nearby of any rivers or deep streams which might have yielded fish, no *muduk* bone fishing toggles were present ". The Capertee River contains eels and perch, and there are many long deep stretches and pools in its bed during normal seasons. *Muduk* have only been found on the eastern side of the Blue Mountains, and are unrecorded from the western side on which the Capertee Valley is situated. The second one is that " a relatively great abundance of points, of types thought to have been used as needles in sewing skins together, may suggest that the altitude and southern exposure of the site was conducive to the use of skin cloaks and rugs ". It is now generally believed, as I pointed out (1943, 1946, 1949, 1958), that the *Bondi* point was a dual spear barb and point, and Mulvaney (1961) has revealed evidence from Loshult in Sweden supporting this claim, but Tindale continues to regard it as an awl or borer, a claim which automatically involves the idea that the making of skin cloaks and rugs began when *Bondi* points originated. A point less than 1.5 cm. long would be very awkward to use for boring skins, and the majority of them are under 3 cm. I have already discussed this matter at length (1958), pointing out that most of the first-hand records of the making of skin cloaks and rugs indicate that a bone awl was the common implement employed for piercing the skins.

HABITAT

Sites 1 to 4 are situated in a rugged gorge in which steep-sided walls alternate with high and low terraces inhabited by swamp wallabies and other game. Most of the rock shelters adjacent to water in the gorges and valleys of this area have been inhabited by the Aborigines, some for a long period. The shelters occur at all levels on the ridges, at the top of the talus slopes, and even on the tops. Strenuous climbing is necessary to reach some of them. Site 5 is situated hundreds of feet above the upper wide portion of the valley, and appears to be difficult to reach from any side. These natives had a forest economy adapted to a mountain environment which yielded ample food and shelter. The population was dense enough to make it necessary for groups of natives to occupy both the rugged gorges and the broad valleys nearby, where better hunting and camping conditions prevailed. The list of animals identified from the bones found in the excavated sites indicates that in the gorges the natives depended chiefly upon the swamp wallaby and possums for their flesh food, and in the open valleys they added the grey kangaroo and the emu. It was evidently not a specific type of food they were seeking. Possibly the local groups were hostile and some lived in the gorges for safety.

Sites 1 to 4 are situated on the southern bank of the Capertee River, which flows eastward for some 20 miles to join the Colo River, which in turn joins the Nepean. As the Nepean and the Hawkesbury are the one river, a route exists along these various streams from the Capertee Valley to the coast. A rock shelter containing stencils occurs near the junction of the Colo and Capertee Rivers. Inter-group contact probably took place along these streams, but to what extent is not known. The ground edge axes found in our excavations are not of local origin, but we cannot as yet decide whether they were made in the mountains, or whether they came from the east or west.

CLASSIFICATION

The classification followed is that of McCarthy, Bramell and Noone (1946) but as this memoir is now out of print the following information is included as a guide to the readers of this paper. All implements under 3 cm. long are regarded as microlithic and their numbers have been quoted for comparison with the macrolithic series.

The coroid group includes all implements not knapped from a core which are either a pebble, slab or lump with a used edge.

In the side and end scrapers all of the implements with a concave or nosed working edge are described in these two groups to illustrate the importance of these two working edges in the industry, and to enable comparisons to be made with other industries in which the same practice has been followed (McCarthy, 1943-1962). The other side or end scrapers possess either straight or convex, or both kinds, of working edge. The notched working edge bears a series of used but small trimmed concaves and convexities, like a coarse saw, made by percussion and not by pressure. The saws have a neatly dentated edge produced by pressure.

The implements classified as knives have a working edge lightly faceted from use on the majority but very neatly trimmed on others. This edge varies from a long shallow concave to straight and convex.

Noone's (1934) classification of burins has been followed because it fits the Australian examples so well. A change adopted, however, is to divide the burins into the major groups of (*a*) coroid in place of nucleoid, (*b*) macrolithic or normal flake and blade, and (*c*) microlithic, with the varieties of spalled, scaled and fluted as defined by Noone. Coroid burins also occur in the microlithic group. As they are not provided for in Noone's classification it was decided to introduce the term into the classification of Australian burins and when this was done the whole series was classified without difficulty.

The specialized implements mentioned in this paper are as follow: *Worimi*, a block with triangular or wedge shaped section; *Elouera*, an asymmetrical blade (often resembling an orange sector in shape), with thick back trimmed on one or both edges, and sometimes bearing use polish on the chord; *Tula* adze, a semi-discoid flake or tongue-shaped blade mounted in gum on the end of a wooden handle or spearthrower. After prolonged use, during which the working edge is re-sharpened a number of times, the adze is worn back to a slug which is discarded. The *tula* slug is produced when the adze is used on the distal end edge, and the *Burren* slug when it is used along both lateral margins; *Glanmire* butt end scraper has a neatly trimmed convex butt which tapers away to a thin pointed distal end; *Bondi* point, an asymmetrical point trimmed along one or both edges of the thick side, and often around the butt; *fabricator*, a flake or blade, often biface and struck by the bipolar technique, with a bi-faceted working edge which eventually assumes a gouge-like shape.

SITES

Sites 1 to 3 form a group in huge blocks of sandstone from 40 to 150 ft. long which weathered out of the cliff in past times and which now rest upon the talus slope. They form a triangle in which sites 1 and 2 are some 200 ft. from the river and the highest one, No. 3, is 58 ft. above 1. They are from 58 to 190 ft. apart. No. 4 is a shelter high up on the ridge, one-third of a mile west of Nos. 1 to 3. No. 5 is on top of the ridge between Running and Nile Creeks, to the east of Crown Station in the Capertee Valley, from which there is a steep and arduous climb to the top of the ridge. It is 10 miles north-west of sites 1 to 4. No. 6 is near Noola Station, 20 miles to the west of Nos. 1 to 4.

SITE 1

This site is 25 ft. long (with a shallow extension 8 ft. long at the southern end), 8 ft. high, 8 ft. deep from front to back, and faces east. The floor, prior to excavation, sloped steeply from the high southern end, which is 4 ft. higher than the northern end. The deposit extended from the back to more than 6 ft. in front, several feet outward at the low northern end, and thinned out markedly up the slope of the floor to the southern end. An area 13 ft. long and 9 ft. wide was excavated in 10 sections. The excavation was taken down to 9 ft. in section 6, and 10 ft. in section 8, but as the table of implements reveals, the true implement zone finished at approximately 72 in., with a few scattered implements below this depth. A hearth of black ash 6 in. thick was uncovered in section 5, at a depth of 3 ft. to 3 ft. 6 in. There appeared to be a comparatively sterile layer between 31 and 36 inches.

Bondaian Layers 1-5

Cores

Those with one platform include a chert pebble 10 x 9 x 6.5 cm., on which the platform has been prepared by the removal of two large flakes at one end. Five are prismatic cores, one pointed at the distal end, and 3.7 cm. long. The majority are irregular lumps on which the platform is formed by the knapping of a flake or block. One is a small remnant, one is a tested and rejected quartz pebble, nine out of the 25 have a dished platform, three have crust platforms, and five are yellow patinated. Six are from 2.4 to 3 cm. long, the remainder from 3.2 to 10 cm.

There are 10 prismatic cores, 2.3 to 5 cm. long, with a platform at each end, varying in shape from thin and narrow to wide and flat backed. The other three are irregular in form. One is a quartzite pebble 8.5 cm. long on which a large flake was struck off each end to form the platforms.

The cores with two platforms at an angle to one another are the most irregular in the series, but several of them have carefully designed platforms at right angles. One is a large chert core 9 cm. long, one is a round-topped core with dished platforms, one is a large chert core 9.5 cm. long with two concave working edges, 7 x 2 cm. in size, on one lateral margin, and one is a chert pebble 6.5 cm. with one crust and one flaked platforms, one 3.5 cm. long has one flat crust and one flaked dished platforms.

The only core, 7 cm. long, with alternate platforms is worked along one side only.

Coroids

They are all made of chert and include: two lumps, 8 and 5 cm. long, with scraper use on one lateral margin; a flat-sided laminated pebble, 15 x 11 x 3 cm., used as a chopper along one oblique but straight-edged end; a flat-sided chert implement 5 cm. long, with a concave 20 x 3 mm.; a flat based lump 5 cm. long with four small rounded noses, each 5 x 3 mm. in size, and a corner nose 8 x 5 mm., separated by concaves 2 x 1, 5 x 2 and 7 x 1 (2) on adjoining margins; a large lump 11 cm. long with a concave 25 x 5 mm., a concave margin bearing four concaves up to 10 x 2 mm., and several faces on which flakes have been knapped; a quartz pebble 3.5 cm. long with a scraper working edge; and a red oxide lump 4.5 cm. long chipped on both lateral margins.

The coroid burins include both spalled and scaled types. In the spalled type is a blade-like piece 5 cm. long, used as a core at one end; it is an (*a*) central type on which the working edge of the burin is formed by two spalls and is 9 mm. wide. A similar piece, 3.5 cm. long, with crust back, has two burin edges, 5 and 9 mm. wide, one of which has been re-struck at right angles to the concave scaled edge.

Re-directing Slivers and Blocks

The slivers are from 2 to 9 cm. and the blocks from 3 to 4 cm. long.

Fabricators

One is a discoid 4 cm. diameter keeled on both sides, heavily used on both ends which are 18 mm. long, one is a spherical quartz pebble 4 cm. dr., and an irregular one, 7 cm. long, has a gouge edge 2 cm. long on one end.

Blocks

Nine chert blocks from 5 to 10 cm. long have either one or two concaves from 6 x 1 to 25 x 4 mm. in size on the lateral margins or distal end. They also bear additional chipping on a straight or convex working edge on these margins. Two are outside spall blocks. One has a rounded nose 20 x 5 mm. between two concaves. One has two concaves on the outer edge of the butt, one is an elongate thick blade-like block 10 cm. long used on a rounded corner nose 20 x 5 mm. in size at the distal end. One is a thick fragment 2.5 cm. long with the edge worked back under the body of the implement. One semi-circular block 3 cm. long has had a flake removed in tortoise-core fashion, and four other blocks, 4.5 to 9 cm. long, have straight to convex working edges, and one has a concave.

There are three blocks of *Worimi* type. One is a heavily patinated chert block, used as a core along one edge from which a large and a small flakes have been removed. The edge of the scar bed of the large flake has been used as a concave 33 x 6 mm., and the long outer edge of the block has been used as a scraper. Two other blocks, not very thick, of quartzite and chert, are both used along the chord on which one has a concave 30 x 5 mm.

Slices

A split pebble slice 13 cm. long, chipped on the inner edge in several places. It is a dark shale with yellow staining, and a perfect fossil leaf (*Glossopteris*) is embedded in the split surface.

Elouera

Two good examples from layer 1. One is of type 2, is 4.5 cm. long and lightly worked on one edge of the thick back. The other example of type 3 is 5.3 cm. long, and notch-trimmed along one edge of the margin. From layer 3 are one of type 1, which is 3 cm. long and trimmed on both edges of the back and right along the chord, and a big example, 5 cm. long, with a concave 20 x 3 mm. on the back of which only one edge is trimmed, and a fabricator-edge on the chord. Both are straight sided.

Scrapers

Half of the side scrapers are on narrow to broad blades, some of which are pointed, and the others are on flakes, from 3.2 to 5.8 cm. with two 7.5 and 8 cm., and eight from 2 to 3 cm. long. Two are yellow patinated. The use varies from partial to full use of the margin. One is chipped on the inner face, one is reverse trimmed on the one margin, and two are used on the thicker side of the flake. One is a large grey and yellow patinated flake 8 cm. long, with a convex working edge, and two are fragments from larger pieces.

The majority of the end scrapers are on blades; only two are on flakes, from 3.2 to 6 cm. long. The working edge of one is oblique, all of the others being convex, and the longest one has two trimmed convex ends. One is an *elouera*-like segment, 3.8 cm., used lightly on one thin edge of the thick side. Two are worked on the inner face, and one is a trimmed edge broken off an end scraper.

There are three flakes, 2.2, 3.4 and 3.8 cm. long, with convex working edge, and a blade, 3.5 cm., with a straight working edge, all used on the butt end.

The one side and end scraper is a broad blade 4.8 cm. long. There is an outside spall blade 5 cm. long, and a keeled blade 2.8 cm. long (one end broken off) used on the inner face.

There are 12 blades and nine flakes from 2.2 to 3 (3), 3.2 to 7, and 10 cm. long, bearing concave working edges. The concave is on the lateral margin of 13, distal end of three, and the butt end of five. One of the butt-end concaves is notched along the distal end, one is a spall flake, and one is yellow patinated. One is a large flake 10.5 x 6.5 cm., with a concave on both lateral margins and distal end.

In the concave and nosed series 11 are blades and four flakes from 1.7 to 2.7 cm. (6), 3.2 to 4.5 (6), 7 to 7.5 (3) cm. long. The nose is on the lateral margin of the majority, on the butt end of one, the distal end of four and occasionally on the corner of the distal end and lateral margin. Five of the noses are pointed, and 12 are rounded. One blade has two rounded and two pointed noses separated by three concaves on the butt end, one is a wedge-shaped blade with a concave on the distal end and a nose between concaves on the lateral margin, one has three noses separated by three concaves, one is a pyramidal flake with two rounded and two pointed noses separated by five concaves, one is used as a scraper on the butt end and has a nose between concaves on the lateral margin. The noses are from 2 x 2 to 14 x 4 mm. in size, and the concaves range from 3 x 2 to 15 x 4 cm., with odd ones 18 x 5, 20 x 4 and 30 x 2 mm.

Knives

All but nine of the 68 are blades from 3 to 8.5 cm. long, the others being flakes from 3.1 to 8.2 cm., with four from 2.3 to 2.8 cm. Their use is invariably on the longest margin, and is demonstrated by light fracturing of the edge or neat and purposeful trimming.

Saws

The only example is a thin fragment 3 cm. long, broken off a larger implement, with a dentated edge 1 cm. long.

Burins

In the spalled type there are four of (*b*), bevel spalled, on three irregular flakes 3·4 to 4 cm. long, and blade 5.6 cm. long. One is formed by one spall 6 mm. wide, one by two parallel spalls 8 mm. wide, one has been re-struck three times and has a working edge 5 mm. wide. The blade of one has been restruck twice and has a working edge 10 mm. wide. There are two of (*c*), rectangular spalled, one on a narrow thin blade 4.3 cm. long, double ended, re-struck twice on one end and four times on the other, with working edges 3 and 4 mm. wide. One is an irregular blade 4 cm. long with a transverse single spall, 5 mm. wide, with a trimmed lateral margin and distal end. Three are of (*d*) convex spalled, on flat-sided blades of chert 4.5 and 6 cm. long. One has a short spall 4 mm. wide, the other has a single spall 7 mm. wide at one end, and at the other end a number of short spalls removed along 10 mm. of the edge which may or may not have been intended for burin use, as this kind of working is common on the cores. A third one, on a narrow blade 3.2 cm. long has a single spall 5 mm. wide. Two are of (*e*) concave spalled, on two narrow blades 3.6 and 4.5 cm. long, both with a single spall 3 and 4 mm. wide. One has a trimmed edge on both sides of the distal end which is pointed.

In the scaled type two are of (*c*) rectangular scaled, one on a narrow thin blade 4 cm. long, which has been re-struck twice on a working edge 4 mm. wide, and one on a blade 4 cm. long, with an inward angled spall 5 mm. wide, is one of the finest burins in the series. Four are (*d*) convex scaled, on narrow thin blades 4 to 5 cm. long, three being formed by a single spall from 4 to 9 mm. wide, the other one being double ended, with working edges 7 and 8 mm. wide formed by single spalls. Three are (*e*) concave scaled, one on a flake 3.5 cm. long, two on blades 3.5 to 5 cm. long. The flake burin is formed by a transverse spall across the corner of the inner face, and has been re-struck. Two of the others are formed by two parallel spalls with working edges 10 and 14 mm. wide.

There are two with spalled and scaled burins on the same implement. One is made on a re-directing sliver 7 cm. long bearing the trimmed edge of the core platform from which it was removed. It is double ended, with single spalls 8 and 9 mm. wide forming the working edges. One end is convex, and the other a scaled concave. The other burin is a flake 4 cm. long with working edges formed by two parallel spalls 9 mm. wide against a concave scaled edge at one end, and at the opposite end two short parallel spalls form a second burin edge 6 mm. wide.

The range of burins is limited to the spalled varieties of the bevel, rectangular, convex, concave, and single blow, and the scaled varieties to the same kinds with the addition of the side and counter scaled ones, all the simpler forms of burins. They occur in the coroid, normal flake and blade and microlithic types. The central or bec-de-flute variety is rare, and the multiple fluted (Noone, 1934, fig. 2, o-p) and nucleiform (Noone, 1934, fig. 1, f) are absent. Features of the series are that the spall is knapped at the opposite end to the platform on 10, the spall has been re-struck on 4, other edges of the implement are trimmed for use on 3, two are double ended, and three parallel spalls have been struck on 5.

Fabricators

Two are thin flakes 2.2 and 3.8 cm. long, used on one lateral margin. and on one end and lateral margin respectively, one is a thick flake with a heavily used gouge-type working edge 2 cm. long, one is a blade 3.5 cm. long with a gouge-type working edge 1.4 cm. long, and a straight working edge 6 mm. long. Five are bipolar blades of punch type used at one or both ends, and five are microliths.

Bondi Points

One is trimmed along the chord but not along the thin margin, one bears light knife use on the chord, one is an elongate segment in shape grading into the geometrical microliths and is trimmed on both edges of the thick back, 4.3 cm. long, and three have a concave—5 x 3, 3 x 1, 8 x 1 mm.—on the trimmed margin. Fifty-six are from 1.5 to 3 cm. and 12 from 3.1 to 4.6 cm. long.

Geometric Microliths

The sizes range from 1.6 to 2.6 cm., with one segment 3.2 cm. Unusual examples comprise a hat-shaped or elongate trapezoid with reverse trimmed sides, and an irregular triangle with a marked concave 10 x 3 mm. on one half of the trimmed back. One is yellow patinated. The segment, trapezoid and triangle are the predominant types, and the oblique trimmed blade (or half trapezoid) is well represented.

Four of the thumbnail scrapers have convex ends, three are side, one is a side and end, and two are double end trimmed microliths from 1.2 to 2.7 cm. long. One has a tiny nose on its trimmed edge, one has a tiny nose between two concaves 5 x 1 and 6 x 5 mm., one is a thin-keeled double end scraper with convex edges, one has straight and convex trimmed ends, one has a concave 3 x 2 mm. on one side and a neatly trimmed chord.

Oblique Trimmed Blades

Three are microliths from 2 to 2.8 cm. long, three others are from 2.3 to 3.5 cm., and one 4.7 cm. has two small concaves on its unevenly trimmed edge.

Hammerstones

Half of a pebble 6 cm. long, well used on its sides, and a pebble 7 cm. long, used on one corner from which a spall has been broken off during use.

Mortar

A pebble 8 x 8 x 4 cm., used as a mortar on one surface and as a hammer on one end which is heavily battered.

Pigment

Two flat pieces of red shale, 4 to 6 cm. long, were found in layer 2. They show no signs of rubbing or use as pigment but the shale could have been a source of pigment.

Yellow Patinated Implements

Sixty-five of the implements in the Bondaian layers are yellow patinated and stained, the remainder vary from firm clean surfaces to discoloured grey from lying in the ashy portion of the deposit.

Capertian Layers, 6-10

Most of the implements in the assemblage are stained and yellow patinated. A number of them have a layer of grit, up to one-eighth of an inch thick, adhering to one surface. The white chert is thus altered to yellow and rich umber brown on the outside, the black chert to grey on the outside. Where the white chert has been lying in an ashy deposit it is discoloured to a grey. All of the implements in this group are made of chert unless otherwise stated.

Cores

Among those with one platform is one 7 cm. long with part crust and part dished flake-scar platform used on the distal end as a hammer; six from 3.5 to 7 cm. long have dished platforms; one is a slab 9 cm. long and 3 cm. thick; one is a tested reject 6 cm. long; one has a concave working edge 25 x 5 mm. in size on one edge, and two have a used concave at the top of a flake scar.

Among the cores with two platforms at opposite ends are two prismatic nuclei 2.8 and 4 cm. long from layers 7 and 8, with two plain and two faceted platforms, and a prismatic core 5 cm. long from layer 11 with one flat crust and one dished and faceted flaked scar platforms. One is a flat and convex sided core 4 cm. long trimmed along both sides. Two are 4 and 4.5 cm. long, and a keeled one is 8 cm. One 9 cm. long is a thickly patinated lump of black chert with two dished platforms.

One of yellow patinated chert 9.5 cm. long, with three platforms from which large flakes have been knapped.

A quartz pebble 4 cm. long has two platforms at right angles, and a core 7 cm. long bears alternate knapping and a trimmed working edge.

Re-directing Slivers and Blocks

The slivers are from 5 to 8 cm., and the blocks from 3 to 4 cm. long. One exceptional piece is a re-directing sliver 9.2 cm. long, deliberately knapped, which bears very neat trimming right along one convex edge and around the distal end.

Coroids

A lump of flat laminated chert, 10 cm. long, 1 to 2 cm. thick, has a convex working edge, and a quartz pebble 4 cm. long has a concave 8 x 2 mm.

Blocks

One 7 cm. long with a concave 30 x 2 mm. on the back edge of the striking platform; one 7 cm. with a concave 8 x 2 mm. beside a reversed concave 15 x 5 mm.; two flat irregular blocks 4.5 and 5 cm. one of which has a concave 10 x 1 mm. and the other two concaves 10 x 2 mm. separated by a notched nose 10 x 2 mm.; one 5 cm. ends in a rounded nose 17 x 10 mm. bearing a used concave 15 x 4 mm. on the inner side; a pyramidal block 3.2 cm. with a notched concave working edge and two concaves 13 x 2 and 6 x 2 mm.; a keeled block 5 cm. with a notched and convex working edge at the distal end, and a keeled re-directing block 5.3 cm. long with a well-used trimmed edge along the keel. A block 6.5 cm. long has a lateral working edge, and one 7.5 cm. long is lightly used at both ends.

Uniface Pebble Implement

A pebble 13 x 7.5 x 4.5 cm., heavily worked over one surface and side to form an oval face, with well-used working edges along the lateral margin extending around both ends. One end has a straight working edge, the other end bears four concaves, of which three are 10 x 3 mm. and one 15 x 5 mm., worked back under the body of the implement. On the lateral margin a long concave 50 x 5 mm. is also worked back in this way. This is a typical Kartan pebble chopper.

Scrapers

Eight of the side scrapers are on blades, the others on flakes, from 3 to 8.5 cm. long, most of them having been used lightly on a straight working edge. One is a thin and narrow blade, lacking its point end, trimmed like a *Bondi* point on two edges of a thick margin. One is made of quartz.

The end scrapers are mostly blades from 2.8 to 3 (3), 3.5 to 5.5 cm. long. Four have convex working edges, and on two the trimmed end is like a broad nose. One is keeled and one is a quartz spall. One is double ended on a flake 4.5 cm. long trimmed on the inner face at one end, and on a narrow straight edged corner at the other end.

Two side and end scrapers on flakes 4.5 and 7.5 cm. long are both poor examples, and a double side scraper is on a blade 4 cm. long.

Notched working edges occur on the lateral margins of two broad flakes 7 cm. long and a blade 8 cm., and on the end of a keeled blade 3.5 cm.

One tiny chip 1.9 cm. long, from layer 10, has a trimmed convex edge on one corner.

The majority of the concaves are on flakes, one being 3 cm., the others from 3.2 to 7 cm., and one 7 cm. long. One is a flake 4.5 cm. with a long concave 36 x 2 mm. across the butt end, one is a pointed flake 6 mm. long with one lateral margin notched and a concave on the other margin, one is a quartz spall with three concaves, and one has a pair of reversed concaves.

The concave and nosed scrapers are mostly on flakes. The blades and flakes are from 2 to 3 cm. (2), and from 3.2 to 7 cm. long. One is a flake 3.5 cm. with a rounded nose on the corner of the butt and a concave on the lateral margin, one is a flat outside spall with a well formed and unusually long narrow nose 10 x 8 mm., like a borer, between two concaves at one end, and a concave at the other end, one is a blade 6 cm. with a rounded nose between two concaves on one lateral margin, and a straight edged nose on a corner at the opposite end, one is a quartz spall with two tiny rounded noses between three concaves. Most of the noses are on lateral margins but they occur on the distal and butt ends, and on the corners of the flakes and blades. Rounded noses are in the majority, but pointed and straight edged ones also occur.

Knives

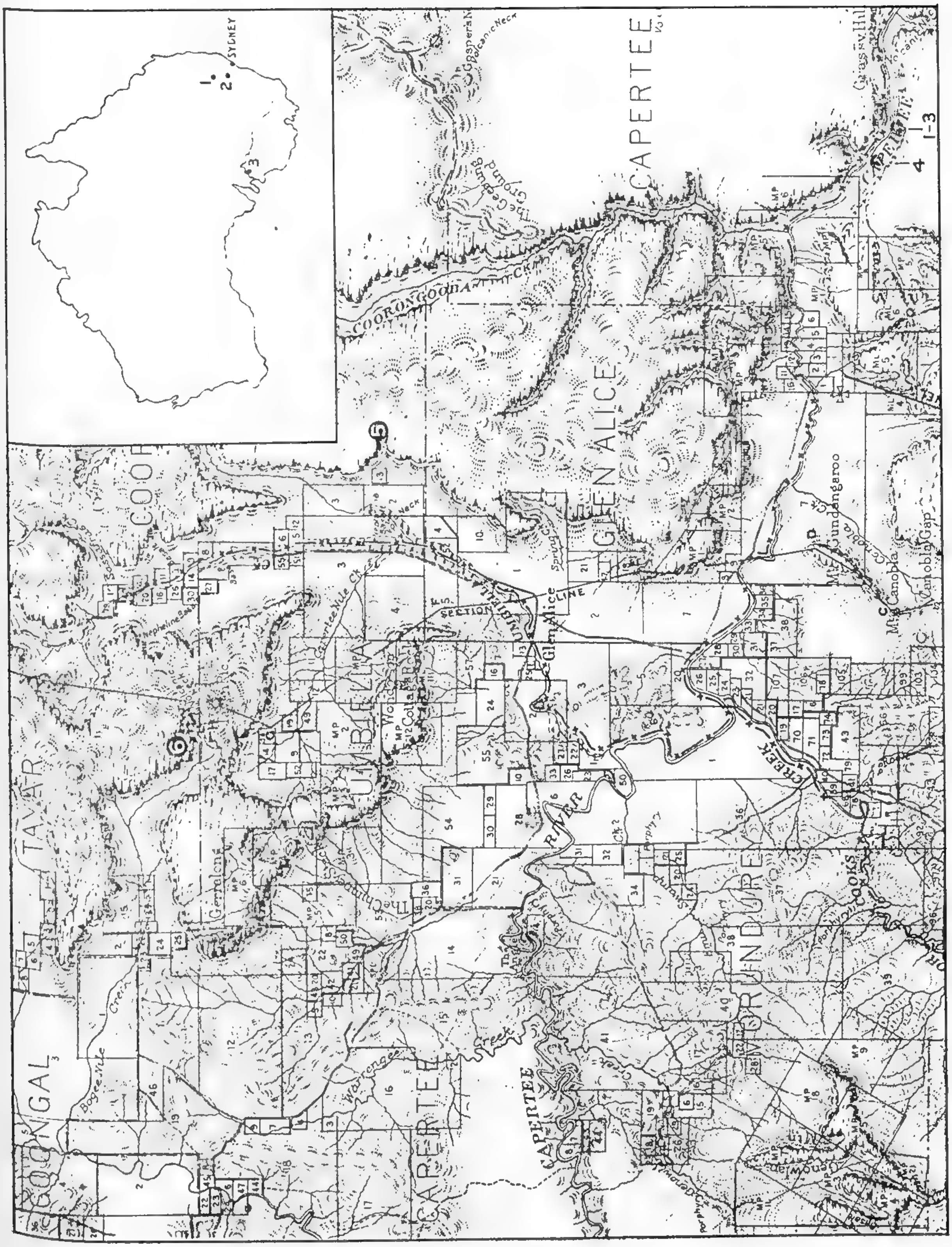
Half of the knives are on blades and half are on flakes, from 2.5 to 3 (6) and 3.2 to 7 cm. long, with one 11 cm. The working edge may be convex, straight, concave or concave-convex.

Saws

The series comprises two flakes 4.5 and 5 cm. long bearing from 3 to 4 incipient but not prominent teeth as the beginning of a dentated edge, a hinged flake 3.7 cm. with a convex dentated edge 2 cm. long, a tongue-shaped blade 4 cm. with a convex dentated edge 3 cm. long, a keeled flake 4.5 cm. with a convex and straight dentated edges on the two lateral margins, and portion (3.5 cm.) of a flake with a delicately dentated edge.

Bondi Points

Two were recovered in layer 7, both lacking tips, one of which is re-trimmed along the broken oblique distal end and has three teeth on the chord. Two were found in layer 8, and one in layer 9, all with broken tips. They are all from 1.5 to 3 cm. long.



Text Fig. 1.—Location of sites 1 to 6, excavated in the Capertee Valley. Outcrops of porphyry and limestone are identified. The major formation consists of Hawkesbury and Narrabeen sandstones, at the base of which cherts outcrop in various places. River and creek alluvials form the floor of the valley. After E. J. Carne, Dept. of Mines, N.S.W., 1906.

Thumbnail scraper

One from layer 9, 2.7 cm. long, with a trimmed convex end.

Hammerstone

A pebble 13 x 9 x 6 cm. used on the lateral margins and ends.

Remarks

Flakes predominate over blades in the Capertian phase. The majority of the 64 implements are stained from yellow to burnt umber, and they are bigger in absolute size than those in Bondaian phase.

SITE 2

This is a low shelter running the full length of a huge elongate block of sandstone lying lengthwise down the slope of the ridge. The shelter is 60 ft. long, up to 5 ft. high, and 8 ft. from front to back, and faces to the west. The deposit extends up to 5 ft. outside the shelter, in one section at the high southern end it fills a shallow area enclosed by rocks, and it slopes from the southern to the northern end. The deposit is up to 3 ft. deep and contains Bondaian implements from top to bottom. The whole of the specimens are described, therefore, as one assemblage.

Cores

An irregular series with flat, dished and cortex platforms, all of chert.

In the one-platform type, from 3.5 to 7.5 cm. long, one has a flat cortex platform and one is a flat sided piece of laminated chert. One is an elongate pebble 12.5 cm. long which has had a block removed from one end to prepare a dished platform, from which one large flake only has been knapped, and there is a concave working edge 3.5 cm. long on the edge of the platform.

The cores with two platforms at opposite ends are from 3.5 to 4.5 cm. and all have dished platforms. One is a flat prismatic core, and one is a tabular type, 5 cm. long, 1 cm. thick and wide. Those with two platforms at right angles comprise one of quartz, 4.8 cm. long, one of chert, 7 cm., and a well-worked one 6 cm. with two dished platforms.

There are two cores 5 cm. long with irregular platforms.

Re-directing Flakes and Blocks

Four slivers from 4.5 to 6.5 cm. long, and one block 5 cm. long.

Coroid Burins

One of (*c*) concave scaled, on a lump 4.5 cm. long, with a working edge formed by one full-length spall 7 mm. wide against a well-trimmed edge.

Blocks

The best examples of blocks from all sites came out of layer 1 in this deposit. They are from 3.5 to 8.5 cm. long. One flat block bears three rounded noses separated by four concaves on the distal end, and has bigger concaves 35 x 5 mm. and 30 x 5 mm. on each lateral margin; one keeled block, 8 cm., is well used on three margins with a concave on one; a keeled block has two trimmed convex ends; a flat block, 7 cm.,

is heavily worked back under the body of the implement on one edge, and has a rounded nose between concaves on another edge; a discoid block 3.5 cm. has a notched concave on a trimmed convex edge; a quartz block has a concave on its thicker end. The majority of these blocks thus bear from one to three concaves. but only one has a trimmed nose.

Slice

One 9 cm. long, with a trimmed lateral margin and a rounded nose on its distal end.

Elouera

One 5 cm. long, slightly used along the chord.

Scrapers

In general, there are more blades than flakes in this series.

Two of the side scrapers are from 2.3 to 3 cm., the others from 3.2 to 5 cm. long. One has a bi-faceted edge, one a steep-faced working edge, and two are fragments. In the double side scrapers, from 3.2 to 4.2 cm. long, two are reverse trimmed, one has a steep-faced working edge, and one bears use polish.

Two of the end scrapers are from 2.3 to 3 cm., the others 4.8 and 5 cm. long. Three have a straight and one a convex working edges.

One side and end scraper is a well fashioned broad blade 8 x 6 x 2 cm., heavily patinated, used on both lateral margins, one of which bears two different coloured patinations, a grey and a yellow, indicating use at two different periods. The only other example is a blade 4.5 cm. long. The only double side and end scraper is a reverse trimmed blade 4 cm. long.

Two of the concave scrapers are 2.5 and 2.7 cm., one of which is quartz, the other from 3.2 to 6 cm., long. One is a keeled blade, 6 cm., with three concaves on one edge, one a thin blade with a concave on both lateral margins, one is a thick keeled blade with two concaves on the chord, one has knife use on one lateral margin and a concave on the other margin. Three are well used butt concaves on flakes 5 cm. long.

In the concave and nosed series one is 3 cm. and the others from 3.2 to 5 cm. long. One is a blade 5 cm. with two rounded noses separated by three concaves on one lateral margin, one has a distal corner nose, a spall flake has a long pointed nose between concaves on the thicker end of a lateral margin, one has a rounded and a pointed nose on the convex end. The working edge is on the lateral margin, and the nose is rounded, on the majority.

A flake 4.6 cm. long has a notched lateral margin.

Knives

Seven blades and four flakes from 3.3 to 8.5 cm. long.

Burins

In the spalled type there is one of (*b*), bevel spalled, one on a flat sided blade of chert 5 cm. long with a single spall 6 mm. wide, the other on a trimmed flake 3.7 cm. long with two parallel spalls producing an edge 10 mm. wide. Two of (*g*), single blow spalled, one on a flake 4.5 cm. long, re-struck, with a working edge 7 mm. wide, and

its other end a trimmed concave edge; two of (*b*), bevel spalled, one on a flat sided blade of chert 5 cm. long with a single spall 6 mm. wide, the other one a triangular flake 3.7 cm. long with two parallel spalls and a working edge 10 mm. wide.

One has been re-struck, one has a trimmed working edge, two have parallel spalls, and two are double ended.

In the scaled type there is one of (*c*), rectangular scaled, on a blade 6.7 cm. long with single spall 6 mm. wide.

Fabricators

Three quartz fragments 1.3, 2.8 and 3.2 cm. long. One is lightly used on one lateral margin and two on adjoining margins.

Bondi Points

There are no unusual points in the series. The majority of the partly-finished points are trimmed at the point end, but two are trimmed on the rounded butt end. Forty-one are from 1.5 to 3 cm., and 16 from 3.1 to 3.8 cm. long.

Geometric Microliths

A well made series of segments 2 to 2.2 cm. long, a triangle 1.6 cm., and six trapezoids 1.5 to 2.5 cm. There are two oblique trimmed blades 2.6 cm., and three thumbnail scrapers 1.6 to 1.8 cm., two of which have convex and one a straight working edges.

Microlithic Burins

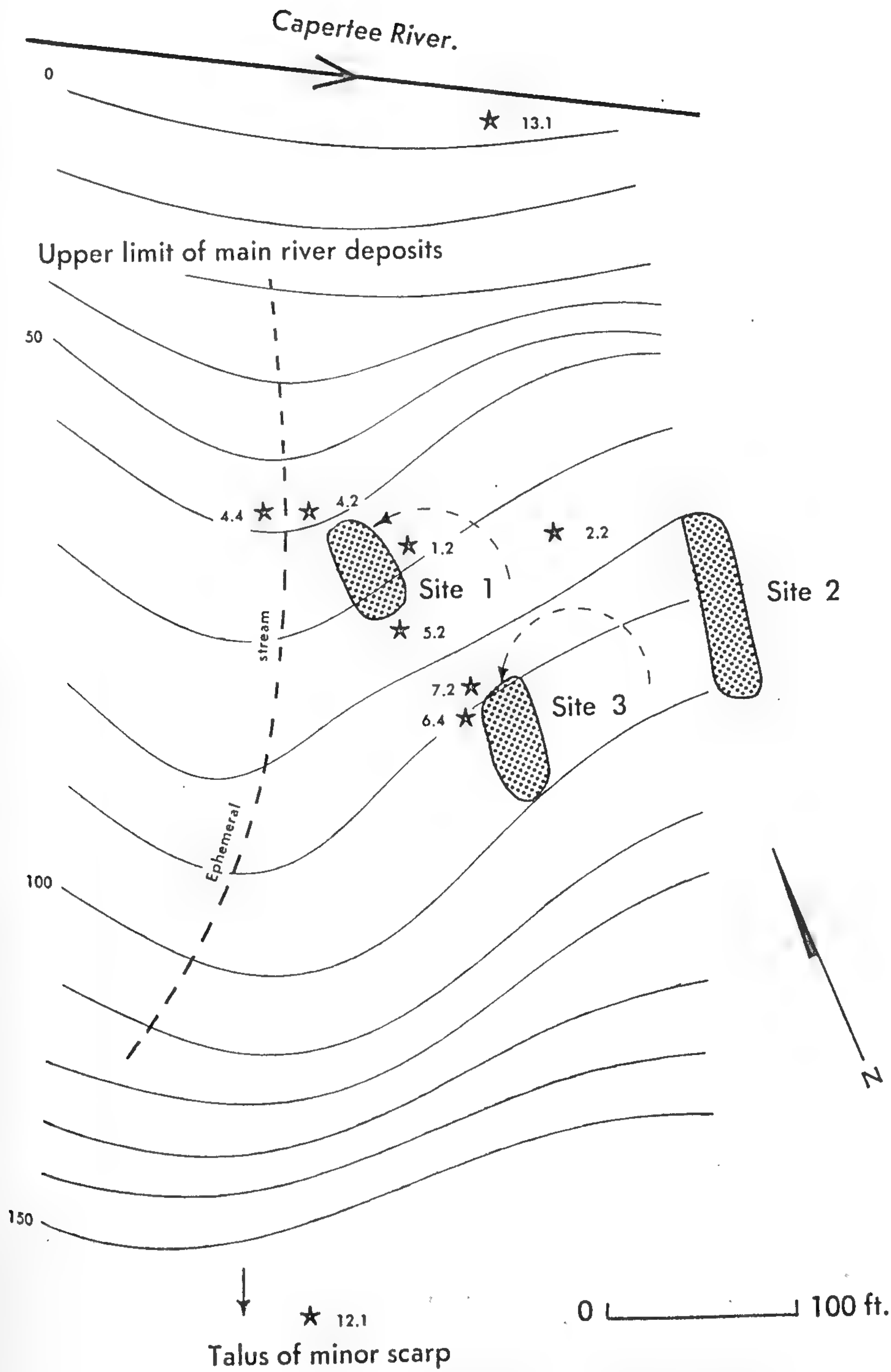
In the flake and blade group two are of (*b*), bevel spalled, one a thin narrow prism 2.5 cm. long with a single spall 3 mm. wide, the other on a flake 2.5 cm. long with three parallel spalls on the end forming an edge 18 mm. wide. One of (*e*) concave scaled, 2.8 cm. long, on a blade with a single spall 7 mm. wide, two of (g), plain or single blow, one on a narrow thin prism 2.6 cm. long with two parallel spalls 6 mm. wide, and one on a blade 2.8 cm. long, used as a burin at both ends of the one lateral margin, with working edges 9 mm. wide. One of (*h*), counter scaled, on a flake 2.6 cm. long.

Hammerstone

A quartz pebble 11 x 6 x 5 cm., heavily used on both ends and sides, with lines of two and three percussive pits on the upper and lower surfaces and one pit on one end.

SITE 3

This site, the last one excavated, proved to be the most important and productive of the series. It was 10 ft. long, 8 ft. high, and 5 ft. from front to back when we began excavation but as the deposit was taken out the shelter was found to be much bigger at a depth of 10 ft. A hole 4 ft. long, 3 ft. wide and from 1 to 3 ft. deep was dug in this deposit by some collectors who were not aware that we intended to excavate the site. The dark ashy deposit varied in depth up to 24 inches, but it formed an extensive pit 54 in. deep in sections 7, 8, 11 and 12, clearly demarcated by its grey colour from the buff-coloured sandy deposit surrounding it. Implements at all depths in this area are coloured according to whether they came out of the ashy-sand pit or from the sandy grit portion of the deposit.



Text Fig. 2.—Plan of sites 1 to 3 in relation tc the Capertee River. (After P. H. Walker).

Another fireplace 4 in. thick was encountered between boulders in section 6 which rested on the basal soil layer T. The main boulder was 4 ft. long, 1 ft. thick, and 1 ft. 6 in. high. An ash sample was collected from this fireplace. A wall of rocks occurred along the front of the cave floor at the 36 in. level, apparently pushed out from the interior by the Aborigines to make more space on the floor. It was somewhat similar to the row of boulders in the Lapstone Creek shelter (McCarthy, 1948).

One of the test holes dug by Mr. Norcross in site 3 (Section 6) was 10 x 6 in. in size, and was taken down 25 in. to the top of layer 5. It was filled with leaves and grass, in which a wooden knife-handle was found 2 ft. from the surface.

Bondaian Layers, 1-5

Ground-edge Axe

The three examples found comprise one of fine-grained basalt from layer 2, a well made biface coroid type 8 x 4.5 x 3 cm., oval section, with flat polished facets on the blade, percussion use along the sides and butt, and anvil marks on both upper and lower surfaces; one from layer 3 is a rectangular pebble axe 9.5 x 8 x 2.3 cm., bearing a few flake-scars on the edge of one surface, which is stained a buff colour and has a convex blade; and a flaked pebble axe, 9.5 x 9 x 3 cm., half oval in shape, made from a weathered lump of basalt roughly flaked along one margin and half of the other one, the convex blade being not quite centred, and the butt hammered heavily to a straight percussion face. Three flakes bearing typical axe blade grinding were found in layers 1 and 3 and are 4.5 and 5.5 cm. long. Two of the axes were found near the back wall of the shelter.

Cores

These are mostly of grey to cream and sometimes of black cherts, some are of quartz and many are irregular in shape. Cortex, flat, and dished platforms are all represented.

Among those with one platform, 16 are from 2.3 to 2.8 cm. long, the others being from 3.5 to 3.7, and three are from 8 to 10 cm. One is a flat sided slab 9 x 6 x 3 cm., and several other smaller cores of this local laminated chert are present. One is a controlled prismatic core, and there are 16 others of prismatic shape. There are three small conical cores. The biggest core is a rounded lump of chert 12 x 13 x 8 cm., with cortex top, dished platform, heavily stained and patinated, found at a depth of 3 ft. on the border between the Bondaian and Capertian culture phases. The remainder are irregular in shape. Six are knapped secondary cores from 3.5 to 6.5 cm. long, and another one, 9 cm., has a concave working edge. Three of the microlithic-sized cores are made of quartz. The flake scars on the majority of these cores are relatively small.

Fifteen of the cores with two platforms at opposite ends are from 2.3 to 2.7 cm. long; others of irregular shape are from 3.2 to 6 cm., one is 10 x 9 x 5 and one 7.5 x 4.5 cm. in size. Twenty-nine are of prismatic type, from 3 to 6 cm. long, one of which has deeply dished and crust platforms. Seven have faceted platforms. This group is mostly of small cores with narrow flake scars (probably for points and microliths) and some of them are difficult to separate from burins.

The cores with two platforms at right angles are bigger in size than those in the Bondaian phase of site 1. There is one 2.6 cm. and the others are from 3.5 to 10 cm., with one 10 x 6 x 5 cm. long. Cortex platforms are common in this series. There are three remnants, 2, 3 and 3.5 cm. long, with three platforms, and two poorly worked discoid cores, both knapped secondary nuclei, 4 and 6.5 cm. long, and an elongate core 8 cm., with alternate knapping.

Re-directing Flakes and Blocks

Out of the total of 94, the exceptionally large number of 57 came from layer 3. Some of these pieces are broad and thick, from 3 to 4 cm. long, but the great majority are narrow slivers from 2 to 8 cm. long. The trimming on some of them is finer than on the blocks and scrapers. There are nine blocks from 3 to 5 cm. long.

One from layer 6 is a sliver 7 cm. long, with very neat trimming on a convex edge, neater than that on any block or scraper in the Capertian phase of this site.

Coroids

A tabular lump, 3.5 cm. long, with three concaves from 8 x 2 to 23 x 4 mm., a quartz discoid 3.5 cm., with concaves 10 x 2 and 25 x 2 mm., an irregular lump of grey chert 10 x 6 x 3 cm. with a straight but notched edge.

A flat sided pebble 14.5 x 8 x 3 cm., with a vertically trimmed face all round, notched completely along its oval outline excepting at one end, and a trimmed oval pebble 16 x 9 x 1.5 cm., alternately and roughly trimmed along both lateral margins and one end, and used as a hammerstone on the trimmed end.

Coroid burins

In the spalled type there are 4 of (*c*) rectangular variety, of which one is a triple burin on a blade with two longitudinal and one transverse burins with single blow working edges 4, 6 and 8 mm. wide; two are on blades 4 and 4.8 cm. long, of which one has a re-struck working edge 3 mm. wide, and one is a flat piece 6 mm. long with three parallel spalls producing a working edge 20 mm. wide.

In the scaled type, one of (*d*), convex scaled, 5 cm. long, with a single spall 5 mm. wide, a trimmed convex distal end, and trimming just below the hinge of the spall scar; one of (*e*) concave scaled, on a flat faced piece of chert 4 cm. long with a single spall 7 mm. wide.

One combined spalled and scaled burin has two parallel spalls struck against a single spall at one end, with an edge 11 mm. wide, and a single spall struck against a scaled edge at the other end, with an edge 5 mm. wide.

The same range of burin varieties occur in sites 1 and 3. In site 3 the spall is knapped at the opposite end to the platform on 8, 10 are re-struck, nine have an additional trimmed edge on the implement, seven have two to three parallel spalls, and four are double ended.

Blocks

An irregular formless series, in which seven are of microlithic size, and the others from 3.2 to 8 cm. long. Many bear only casual use, with an occasional well-trimmed edge. One has a steep faced edge, one is trimmed on the inner face, and one is reverse trimmed on two adjoining long edges one of which bears two concaves 10 x 2 mm. in size. One pointed block 5 cm. long has a concave 15 x 2 mm., and a convex working edge, one has a concave 14 x 3 mm., one has two concaves 30 x 3 and 5 x 3 mm., one has a nose 10 x 4 mm. and a concave 18 x 3 mm., and one has two concaves 10 x 2 and 15 x 2 mm. One has a notched edge, two have corner trimmed working edges, one has a straight bi-faceted cutting edge 4.5 cm. long, and two are keeled. One is made of quartz.

Slice

One 10.5 x 9 x 3.5 cm. of grey chert is of cleaver type with a straight bi-faceted working edge 6 cm. long, and another straight working edge 7 cm. long. Another rough slice of grey chert 9.5 cm. long, with one long concave and convex working edges, and one 9.5 cm. with a concave 10 x 4 mm. on the corner of the trimmed distal end.

Blade

One 9.5 cm. long struck from the outside of a chert pebble, with light use on one lateral margin.

Scrapers

A somewhat formless series on which the proportion of measurable butt angles is low, blade shape is in higher proportion than flake, and the working edge is from straight to convex. Salient bulbs are uncommon.

Nineteen of the side scrapers are from 2 to 3 cm. long, three of them are quartz, the balance are from 3.2 to 7 cm. One is a thin flat-sided piece of laminated chert, one is used on the inner face, but the chipping or use generally is scrappy and haphazardly placed.

Eight of the end scrapers are from 1.7 to 3 cm. and the balance are from 3.2 to 8 cm. long. The working edge is convex on the majority, and straight on the minority. Five are of quartz. One is a neat tongue shaped blade, the others of irregular shape. Two keeled blades 6 cm. long have a trimmed oblique distal end. Six of the butt end scrapers are from 3.5 to 5 cm. long, one is a re-directing sliver 10 cm. long bearing a concave 75 x 10 mm. Nine of them are *Glanmire*-type keeled flakes tapering from the thick chipped convex butt to the thin pointed distal end, three of which are from 2 to 3 cm., and three from 3.3 to 3.5 cm. long. Four of the double ended scrapers are blades 5 to 6 cm. long, one 3.5 cm. has a trimmed lateral margin, and one 3.5 cm. is trimmed across a broken straight edge on one end.

Five of the side and end scrapers are from 2 to 3 cm. and the others are from 3.3 to 3.6 cm. long, with one 6 cm. and the biggest one 8.5 x 8 cm. One is a pointed blade, 6.4 x 4 x 2 cm., bearing the remnants of gum (probably beeswax) hafting. It was mounted so that one long margin projected from the gum. Half of this edge is heavily worked with step chipping which extends around one end for 1 cm. and most of the striking platform has been worked away as a result. Four of the double side scrapers are from 2.5 to 3 cm. and the others are from 3.5 to 6 cm. long. One is reverse trimmed. The longest one has two straight working edges. Three of the double side and end scrapers are reverse trimmed, and most of their working edges are straight.

There is an irregular semi-discoid scraper 4 cm. long, and a discoid 4 cm. long. One discoid 3.5 cm. bears small flake scars alternately knapped and is a core used as a discoid.

Tula Adze Slug

A typical example was found in layer 3. It is 3 cm. long, 1.5 cm. from butt to working edge, and is fire burnt.

Elouera

Although only a few specimens were found they were distributed through the deposit down to layer 5. They are from 3.25 to 8 cm. long. Two are use-polished on the chord, one of which is a shallow concave and the other a lightly trimmed edge. All of them are trimmed on one edge only of the thick back, and on one the trimming extends around the distal end. One is lightly faceted on both sides of the chord as though for cutting, and one has a trimmed chord. The biggest example is roughly shaped along the thick back, heavily used and use-polished on the chord.

Backed blades

Three narrow blades from 3.5 to 6 cm. long.

Knives

The majority are blades varying from thin and narrow to broad and thicker pieces, and several are flakes, of which eight are from 2 to 3 cm. long, the others being from 3.2 to 8 cm. The working edge, which is lightly faceted on the majority and lightly trimmed on one, is from straight to convex.

Saws

Ten are from 1.8 to 3 cm., the others are from 3.3 to 5 cm. long, thus being comparatively small flakes and blades. The saw is on a convex lateral margin on the majority, but it is on the distal end of two, butt end of one, oblique edge of one, is straight or concave on several others. It is 7, 10 (3), 15 (2), 20 (2), 25 (2) and 30 mm. long. One thick flake 2.1 cm. has the dentated edge on a notched end, one is a triangular flake 3 cm. with a nose-like saw-edged end, one with a dentated edge 25 cm. has obviously been broken off at each end, and one from layer 1 has incipient saw edges.

Concave

Eleven are from 2 to 3 cm. long, the others are from 3.5 to 7 cm. Most of the concaves are on lateral margins. One is a semi-discoid of quartz, 2.4 cm., a punch type blade 2.25 cm. has two concaves, one blade 5 cm. is double side and end trimmed and a similar one has the concave on the corner of a heavily faceted butt, one blade 2.5 cm. is a reverse trimmed double side and end scraper with a concave on the end, one is a butt end concave on a narrow keeled blade 3.5 cm., one is reverse trimmed with two concaves on each lateral margin.

Concave and Nosed

Three are from 2.5 to 3 cm. long, the others are from 3.5 to 7.5 cm. The noses are mostly rounded, but pointed noses occur sometimes combined with a round one. One has three pointed noses. One nose has a notched edge, and one has a concave 8 x 2 mm. on it, one blade has a broad nose right across its end, but on two examples the set of a tiny nose between concaves occupy only 1.5 cm. of the edge. Two have the nose on the distal end, one is a curved blade with a nose between two unused concaves on the distal end, three blades each have two noses separated by three concaves on the distal end, five have the nose on a distal corner with or without adjoining trimmed margins, one is a keeled blade 8 cm. with a notched straight end, pointed nose between concaves on a corner and a broad nose between concaves on a lateral margin.

Notched

Four are from 2 to 3 cm., the others are from 3.5 to 7 cm. long. The working edge varies from concave to straight and convex, it is on the lateral margin of the majority, on both lateral margins of one, and on the lateral margin and end of one. It occurs on both flakes and blades. One is a wedge-shaped blade 7 cm., one has a convex and a concave notched edges, one is a flat piece of local laminated chert 6 cm. with a notched concave edge 3.5 cm. long, one is an outside spall. The biggest one has a notched concave 40 x 5 mm. lateral margin, and the corner of its distal end is a rounded nose 40 x 20 mm. trimmed on the outer face of one side and the inner face of the other side, with a concave 20 x 5 mm. on the other margin.

Burins

Two of the spalled burins are of (*c*) rectangular spalled, both 3.5 cm. long. One has two parallel spalls with a working edge 4 mm. wide, the other has been re-struck three times and has a working edge 7 mm. wide, and the opposite lateral margin is trimmed on both examples. One is of (*d*) convex spalled, on a blade 5 cm. long, re-struck with a working edge 5 mm. wide. One is of (*e*), concave spalled, a double ended burin on a blade 4 cm. long, with a single spall 7 mm. wide at each end. Six are of (*g*) single blow spalled, two on blades and three on flakes 3.5 to 4 cm. long, three with a single spall from 3 to 7 mm. wide, two with two parallel spalls and a working edge 8 and 10 mm. wide.

Four of the scaled burins are of (*c*) rectangular scaled, one on a blade 4.5 cm. long with a single spall 4 mm. wide, one on a blade 5.3 cm., with an inward angled spall 7 mm. wide and slight trimming on the other lateral margin, one is on a re-directing sliver 6 cm., re-struck, with a working edge 8 mm. wide, one is a double-ended burin on a narrow blade 4.3 cm., one a single spall 10 mm. wide, the other with two parallel spalls 10 mm. wide. Seven are of (*e*) concave scaled, all on blades from 3.3 to 5.3 cm. long, five of which have a single spall from 6 to 9 mm. wide, one is re-struck with a working edge 4 mm. wide, and one is a double with a single spall working edge 3 and 6 mm. wide at each end of the scaled edge. The latter specimen has a trimmed distal end. Six are of (*d*) convex scaled, three of which are on narrow blades 4 to 5 cm. long, each with one spall from 2 to 9 mm. wide, but one has been re-struck, one is on an unusually big *Bondi* point 5.5 cm. long which has been re-struck, and two are on thick irregular blades 4 to 5.5 cm. long, one of which is a single spall 5 mm. wide, and one has two parallel spalls 8 mm. wide. One has a trimmed distal end.

One is a blade 5 cm. long, with a single blow spall 9 mm. wide at one end, and two single blow spalls 6 and 13 mm. wide against a scaled edge at the other end.

Fabricators

The great majority, 17, are from 1.8 to 3 cm. long, the others are from 3.3 to 4.5 cm. Twelve are bipolar struck blades. The working edge varies from lightly to heavily used, five have curved gouge-type working edges, sometimes combined with a lightly worked edge on the opposite end or lateral margin. One thin blade has a gouge-type edge on both lateral margins. The working edge is from 1 to 2 cm. long. Two nucleoid examples have gouge-type working edges.

Bondi Points

Unusual points comprise the distal portion only, 1.7 cm. long, of one whose chord is a concave working edge 10 x 2 mm., one with a dentated chord on which the teeth are small and not as definitely formed as on the flake and blade saws, one with a fully trimmed chord, one with the chord trimmed near the point, one with three

concaves 8 x 1 and 10 x 2 (2) on the chord, the butt half of a big point with two concaves 8 x 2 mm. on the butt and on the back, both worked back under the edge. In layer 5, five out of the seven points are from the 25 to 30 in. level, and the other two from 31-36 in.

There is one bi-marginal point, 3.5 cm. long, with a plain butt. It is yellow patinated and lacks its tip.

One hundred and sixty-six are from 1 to 3 cm. and 38 from 3.1 to 5.2 cm. long, seven are middle fragments, 33 have the tip and 20 the butt broken off, and 27 are yellow patinated.

Geometric Microliths

The 19 segments, 13 trapezoids and seven triangles are from 1.3 to 3 cm. long. The segments vary from elongate narrow (grading into the *Bondi* point) to broad semicircular shapes, and one has a trimmed chord. The trapezoids also vary from elongate to broad types, with either trimmed or untrimmed back, and one displays slight use on its chord. The triangles vary from elongate isosceles to broad equilateral shapes. Four have broken tips and four are yellow patinated. Many of them are equally as well made as geometrics from elsewhere in Australia and as a whole they form a very well developed series.

The oblique trimmed blades are from 2 to 3 cm. long.

Thumbnail Scrapers

These scrapers vary from thin concavo-convex to thicker types trimmed on the convex distal end, lateral margin or on both end and side. Four of them are discoids. One pointed flake is heavily used on the inner face. One is trimmed on three edges, with a concave 13 x 2 mm. on one. One is an unusually neatly made oval piece trimmed on both lateral margins and distal end. One is a quartz spall 1.6 cm. long trimmed on four straight edges.

Microlithic Burins

In the coroid type one is a double ended burin 2.2 cm. long with a single spall 8 mm. wide against a convex scaled edge at one end, and a single blow spall 6 mm. wide against a plain platform at the other end.

There are four burins of (*g*) single blow spalled, one a narrow prism 2.9 cm. long, re-struck, with a working edge 4 mm. wide, and three are of irregular shapes, from 2.2 to 2.8 cm. long, with parallel spalls 5, 10 and 20 mm. wide.

There are two of (*b*) bevel spalled, both with a single spall 3 mm. wide. They are 2.1 and 2.9 mm. long.

In the scaled type there is one of (*c*), rectangular scaled, a tabular blade 2.7 cm. long, re-struck with a working edge 7 mm. wide and trimmed distal end; four of (*d*) convex scaled, one on a flake 3 cm. long, three on tabular pieces 2.3 to 2.8 cm. long, all with single spalls from 3 to 6 mm. wide. One of the latter and the flake have trimmed edges; one of (*e*) concave scaled, 2.5 cm. long, with a single spall 5 mm. wide. On the opposite corner to the burin edge is a trimmed sharp point like a borer.

Gum-hafted Microlith

The head of the beeswax gum haft is 20 mm. long, 18 mm. wide and 13 mm. thick. Set in the middle of the top, and at right angles to the long axis, is a fragment of quartz 13 mm. wide and 2 mm. thick, projecting up to 4 mm. from the gum. The flake has a slightly rounded convex upper edge which shows no definite signs of use, and it would in fact, probably be discarded as a waste fragment if not so mounted. It is not a geometrical microlith, but it could have been used as a graver. There is a channel in the inner surface of the haft which shows quite clearly that it once held a thin rounded wooden handle 10 mm. wide and square ended.

Use-polished

There is only one narrow ridged blade 4 cm. long, and three of the *elouera*, bearing this kind of working edge.

Hammerstones

Pebble broken through the middle, 5 x 6 x 2.3 cm., one end of which has been used as a hammer and the other end has an abraded broken face. Part pebble 10 cm. wide and 2.8 cm. thick used around the sides. Pebble 10 x 8 x 5 cm., with one end flaked as a result of percussive use. These are all quartzite.

Shell ornament

A thin oval concave-convex piece of mussel shell, 1.8 cm. long, perforated at one end for threading on a string necklace. It is almost transparent and is stained a buff colour.

Patination

One hundred and thirty-five implements are stained from a yellow to a rich ruddy brown, and some also with manganese in all layers, there being 14 in layer i, 23 in ii, 36 in iii, 31 in iv and v.

Capertian Layers 6-11

Cores

Among the cores with one platform six are from 2 to 3 cm. long, and the others are from 3.2 to 9.5 cm., of which 20 in the bigger group are 5 cm. long. There is a mixture of flat and dished platforms, and cortex platforms are common, there being four out of seven in layer 9. Only two are prismatic in shape. Ten are made of quartz and are from 2.3 to 8.5 cm. long with both knapped and cortex platforms. Several cores have used concaves from 10 x 2 to 25 x 4 mm. in size, and two of the bigger ones, 20 x 4 mm., are heavily worked. One is a small core of black banded chert from layer 9 of which a flake was found in layers 3 and 6 above.

Although the two platforms are at the opposite end of the knapping face on 13, only two are prismatic in shape. One is 2.3 cm long, with a well used concave on the edge of the platform, and the others are from 3.2 to 8 cm, the biggest being 15 x 10 x 5 cm. Two are of quartz and are 4.3 and 7.5 cm. Those with two platforms at right angles are from 5 to 6.3 cm. long. There are seven with three platforms, from 4 to 7 cm. long, one is 11, and one is 9.5 x 8 x 5.5 cm. with three dished platforms.

Re-directing Slivers and Blocks

There is a notable decrease in the number of these flakes, accompanied by an increase in the relative number of bigger pieces in comparison with the slivers. The slivers are from 2 to 5 cm., and the blocks from 5 to 8 cm. long.

Coroids

A scanty series comprising a quartz pebble 9.5 x 6 x 3 cm. with knapping platforms at each end and a well used chopper edge on one lateral margin, and three smaller coroids, one of chert 4.5 cm. has a concave 15 x 2 mm. on the end, and two of quartz 3 cm. with convex, and a concave 8 x 3 mm., working edges.

Uniface Pebble Implements

There are five from layer 7. One is a chert pebble 10 x 12 x 4 cm., with a straight working edge diagonally across the middle, the balance of the pebble having been worked or flaked away. One is an almost rectangular hornfels pebble 13 x 7.5 x 4 cm., split through the middle lengthwise to produce a flat upper surface with a working edge 7 cm. long at the distal end which bears two concaves 20 x 3 and 10 x 2 mm. One is a quartz pebble 8.5 x 6 x 4 cm. with a concave 25 x 4 mm. on its lateral edge. One is a large slice from a basaltic pebble 7 x 7 x 3 cm. with a concave 20 x 5 mm. on its thick margin. One is a chert pebble 5.5 x 5 x 2.5 cm. with a broad convex nose-like working edge 20 mm. long. One from layer 8 is a pebble 11 x 6.8 x 5 cm., with a convex working edge bearing concaves 18 x 3 and 19 x 3 mm., and a nose 12 x 5 mm. Another one from this layer is a ferruginous pebble 10 x 5.5 x 2.8 cm., with an uneven and lightly used working edge.

Blocks

These are from 3.2 to 10 cm. long, with four of quartz from 3.5 to 3.7 cm. The working edge is on the distal end of 13, on the lateral margin of nine, and on the butt end of one. There are five elongate pieces and four are keeled. One is an oval core used as a block scraper on a convex nose-like corner 20 mm. wide. The concaves range from 5 x 2 to 13 x 4 mm., and trimmed noses from 10 x 1 to 10 x 6 mm., and both are common on these blocks. One has a concave 8 x 2 mm. beside two very small noses on one end, one is a semi-discoid with concaves 10 x 3 and 13 x 3 mm. alternating with noses 20 x 4 and 20 x 6 mm. on one edge, one has a concave 15 x 4 mm. beside a nose 10 x 5 mm. on the end, one is a reverse trimmed block 6.5 cm. long with a nose 20 x 5 mm. between two concaves 20 x 5 mm. on one edge and a nose 10 x 3 mm. beside a concave 15 x 2 mm. on the other edge. Three have long concave notched working edges, one has a short notched working edge, and one 8 cm. long has a notched concave 35 mm. long and a nose 20 mm. wide on a butt end corner.

There are two *worimi* choppers, both 8 x 7 x 6 mm., one made of chert and the other of quartzite. The former has a well used chord and is trimmed on both edges of the thick back.

Slices

One is a yellow patinated slice 12 cm. long, lightly used on one convex side with a used concave end 4 mm. wide. One is a dark chert slice 9.5 cm. long, well used on a convex side and on a concave end 10 x 3 mm. wide with a nose 5 x 5 mm. on the corner. One 11 x 9 x 4 cm. has a concave 20 x 3 mm.

Blades

One 13 cm. long, triangular in section, with slight use on one lateral margin, and one 7 x 7 cm., with a heavily used convex working edge faceted on both sides.

Scrapers

Blades are in slightly higher proportion to flakes in this series.

In the side scrapers four are fragments from 2.6 to 3 cm. long, the others are from 3.4 to 7 cm. Convex and straight working edges are evenly represented. Two are trimmed on the inner face. One is a blade 7 cm. long trimmed right along one lateral margin, three are quartz scrapers one of which has a convex working edge on a distal corner.

Among the double side scrapers is a pointed flake 7 cm. long, reverse trimmed, a blade 6 cm. long ends in a nose 10 mm. wide on the distal end, and the best example is a blade 6 cm. long with a spur dividing two well used working edges on one lateral margin. Two others are 4.5 and 7 cm. long.

Three of the end scrapers are from 2 to 3 cm. long, the others are from 3.2 to 7.5 cm. They are mostly irregular in shape. Thirteen have a convex and eight a straight working edge. One of red chert, and a keeled one of grey chert, are blades 7 cm. long. Two are made out of a hard black and white laminated chert, which occurs also in layers 3 and 6.

The side and end scrapers are mostly blades, two being spalls, and they are from 4.5 to 6.8 cm. long.

There are four good examples of semi-discoid scrapers from 3 to 5 cm. long, one made of quartzite and the others of chert.

The majority of the concave working edges are on the lateral margins of a mixture of flakes and blades, eight of which, including three of quartz, are from 2.2 to 2.8 cm. long, the others being from 3.3 to 6 cm. The butt end concaves are on flakes 2.5 and 3 cm., 3.5 to 6 cm., long, and one has two concaves.

The concave and nosed scrapers form an important group. They are mostly on irregular flakes and blades, with no consistent pattern of shape, of which six are from 2.3 to 2.5 cm. long, and the others from 3.2 to 8 cm. The concaves and noses are on the lateral margins of 28, the distal end of 42, and the butt end of three. The rounded nose predominates over the pointed one. From one to four noses, separated by concaves, occur on the one working edge and/or one end, and a tiny rounded nose between concaves on a lateral margin; a flake 4.5 cm. long has a rounded nose between concaves on two distal corners, and a convex notched working edge; a thick square flake of dark chert has three pointed noses separated by concaves, a triangular flake 7 cm. long has a large nose between concaves separating noses, one has a broad rounded nose and a pointed nose between three concaves, a discoid has five noses and five concaves, one flake has two pointed noses, one has a small pointed nose beside a saw-edged concave, a blade 8 cm. long has a large nose on both lateral margins which are reverse trimmed, and a Tasmanoid-like flake 6 x 6 cm. has three noses separated by concaves on the distal end. There are seven irregular and utilized flakes ending in a rounded or pointed nose, of which one blade 4 cm. long has a borer-like end, and there are three butt end nosed and concave scrapers.

There is a good series of notched working edges on flakes and blades from 3 (2) to 5.5 cm. long, on straight, long, shallow, concave and convex edges. One is a dark chert spall with a thick back, 6.5 cm. long, heavily notched along the chord.

Knives

Twenty-eight are on blades and 22 on flakes, of which eight are from 2.4 to 3 cm., and the others from 3.2 to 8 cm. long.

Saws

The finest examples of dentated edges from the Capertee deposits came from layers 6 to 10 in this site. A majority of them are irregular flakes but some are well-shaped blades. Five are from 2.5 to 3 cm. long, the others are from 3.2 to 7.5 cm. The dentated edge is from 1 to 2 cm. long on 22, 2.1 to 3 cm. on nine, 3.5 cm. on one 4 cm. on one, and 5.5 cm. on one. It is, therefore, quite short on the majroity, but is longer on the finest examples. It is on a shallow concave edge on six, a straight edge on seven, a concave edge on 15, and a combined convex and straight edge on one. Nine are fragments from bigger saws, a high proportion of breakages. One 4 cm. long from layer 9 has a dentated edge extending along the straight lateral margin and round both corners on the ends; one has two dentated edges, one has a very finely toothed concavo-convex edge, one blade has a convex dentated distal end, and the finest specimen, a pointed blade 7 cm. long, has a convex edge 5.5 cm. long and a concavo-convex edge 2 cm. long, both dentated.

Fabricators

Nine are made of quartz, one of which is a spall, seven are of punch-type used on one or both ends, and some of them are bipolar knapped blades. A chert example 6 cm. long from layer 7 has a working edge 4.5 cm. long. Two are from 2.5 to 3 cm. long, the others are from 3.5 to 6 cm.

Geometrical Microlith

A segment 3.1 cm. long, yellow patinated, from layer 8.

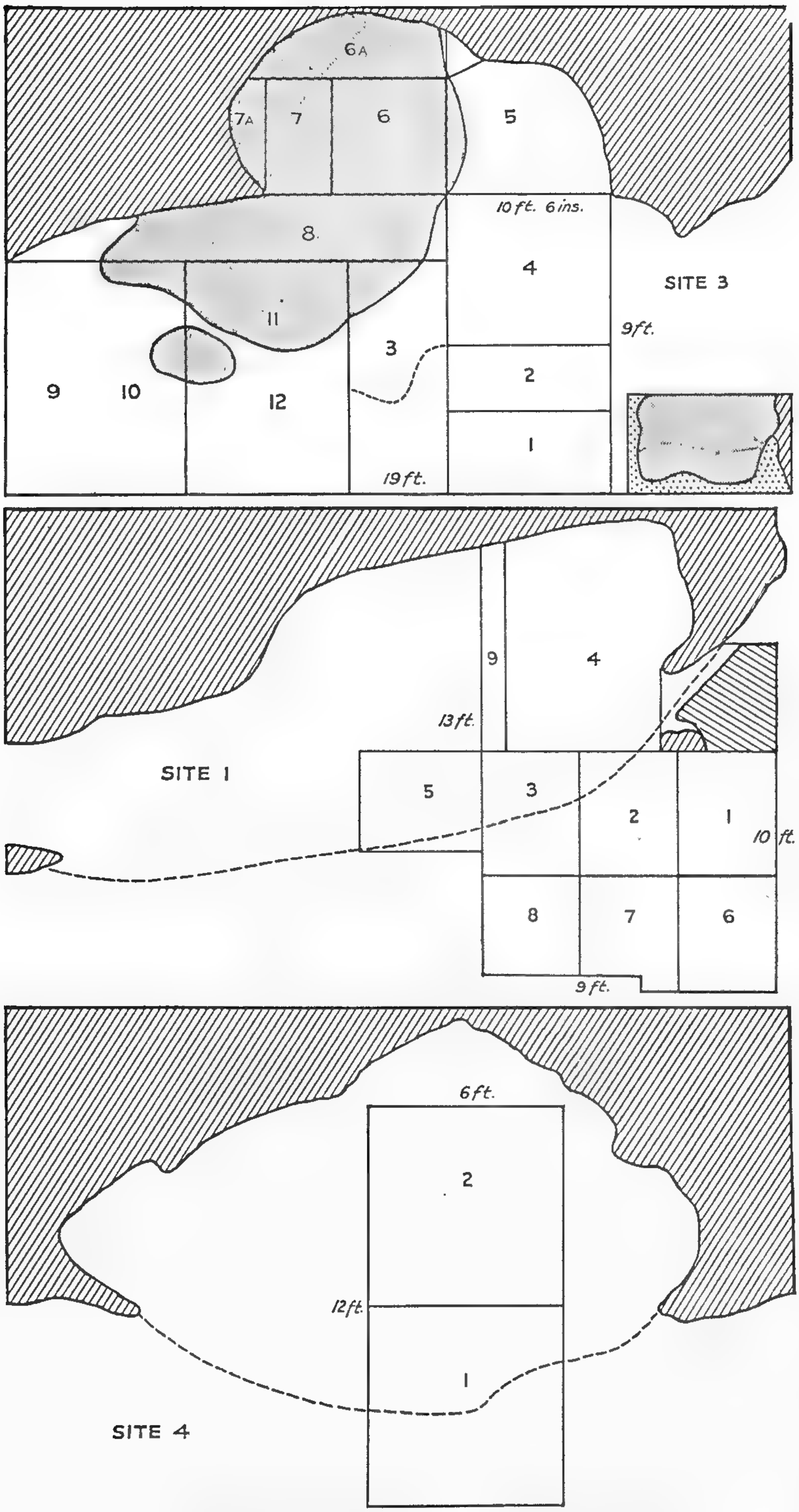
Hammerstones

A sandstone pebble 10 x 9 x 6 cm., used at both ends, and two quartz pebbles, 4 and 6 cm. long, broken by use.

SITE 4

This site is situated about 100 ft. up the ridge, at the top of a grassy slope, and above a broad terrace some 50 ft. above the river between sites 1 to 3 and Freshwater Creek. It is 16 ft. long, 4 ft. high, and 10 ft. from front to back. The floor slopes 1 ft. over the full length of the deposit.

The two 6-in. layers from 7 to 18 in. yielded *Bondi* points, none being found in the top 6 in. which is a loose sandy accumulation formed since the Aborigines left the site. At a glance the industry appears to be a mixture of Bondaian and Capertian, particularly the scrapers and cores, and is a good illustration of the continuity of the Capertian tradition in the Bondaian period. The whole of the implements are described as one Bondaian cultural assemblage because of the presence of *Bondi* points throughout the deposit.



Text Fig. 3.—Ground plan of sites 1 to 3, showing areas excavated.

Cores

In the cores with one platform one has a dished and two have flat platforms, and one has been used for scraping purposes on a trimmed convex edge. Two are 2.5 and 3 cm., two 3.4 and 7 cm. long. There are three prismatic cores from 3.7 to 6.3 cm. long, two of which have heavily faceted platforms. A core 6.5 cm. long has two platforms at right angles.

Block

A flat topped microlithic block 2.8 cm. long with a convex working edge.

Scrapers

These comprise a side scraper 4 cm. long on a flake lightly used; a reverse trimmed double side scraper on a blade 3.4 cm. long; a keeled blade 9 cm. long with trimmed convex distal end, and knife use on one lateral margin, and a convex butt end working edge on a thin flake 3.5 cm. long; a large re-used keeled blade 6 cm. long with concaves on both lateral margins, and a keeled blade 3.5 cm. long with a fresh straight working edge on one lateral margin, and on the other a nose between concaves all weathered from previous use.

Burren Slug

One 2.2 cm. long, heavily worked from both lateral margins towards the middle leaving a narrow central portion of the butt platform.

Knives

Three blades 3.5 to 9.5 cm. long, used on long margins and two flakes 5 and 7 cm. long used on an end edge.

Bondi Points

Two are exceptionally big points, one 5.5 cm. long with untrimmed butt end, and one of the same size lacking tip but well trimmed on one edge and across the straight butt. Three are from 1.9 to 3 cm. long.

Geometrical Microlith

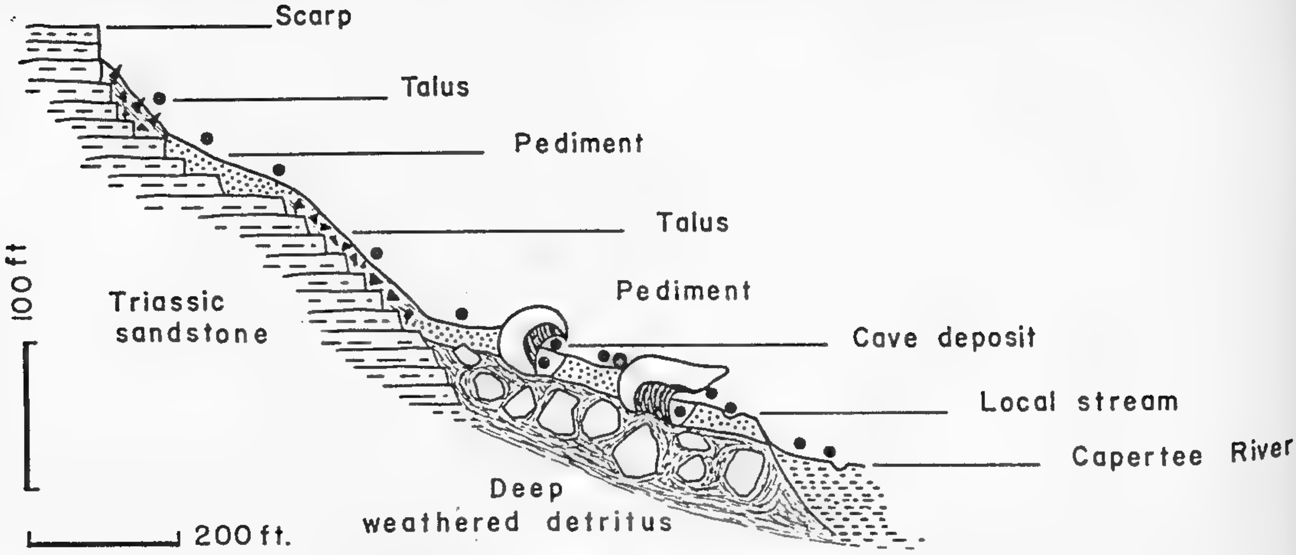
A broken trapezoid segment 1.7 cm. long.

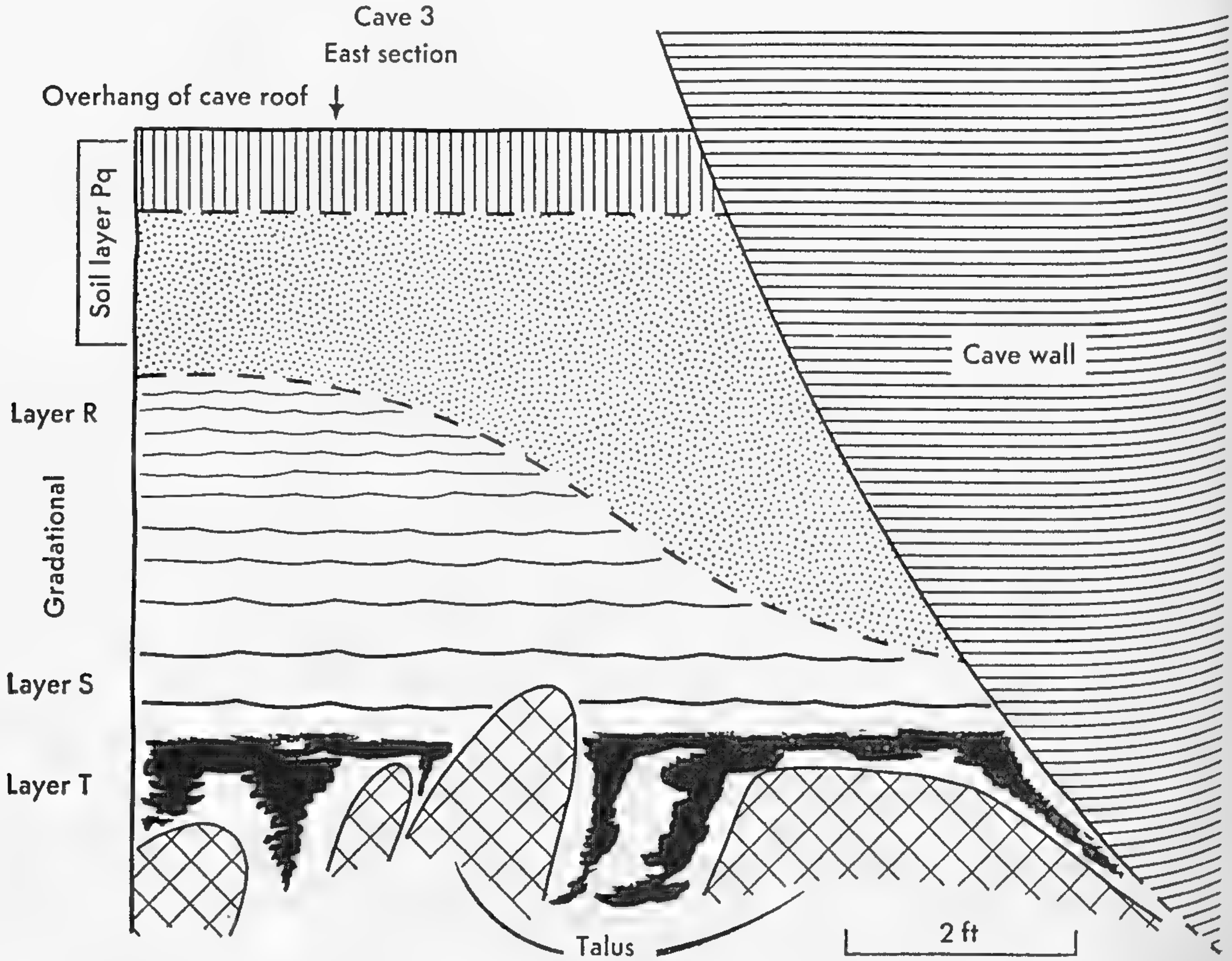
Hammerstone

A pebble of ferruginous sandstone 10 cm. long, with flake scars at both ends left by flakes removed by percussive use.

Bone Points

One is a bone 9 mm. in diameter at the butt which is rubbed on one edge at the point end to form the working edge, and a sliver has been removed from the other edge. One is a complete bone 7.5 cm. long rubbed on one facet to form an awl-type working edge.





Text Fig. 4.—The upper diagram illustrates a section of Capertee Valley, showing the various landscape features, and the places (shown by a black dot) sampled by Mr. P. H. Walker in his investigation of the soils. The lower figure shows the soils in the east section of site 3. The occurrence of stones is omitted except to show the position of the talus. This section is free of cave soil such as occurs in site 1, and the soil layers are generally conformable. (After P. H. Walker).

SITE 5

This shelter is a very big one, 100 ft. long, 35 ft. high, and 27 ft. from front to back. It faces the south-west and looks out over the very wide and flat top, like a small plateau, of a ridge situated between Umbiella and Running Creeks, east of Crown Station. It is an excellent shelter for habitation, with permanent water nearby, but there is a very stiff climb to it from Capertee Valley on the western side and the Aborigines may have approached it from another direction. The deposit is from 19 to 24 in. deep from the surface to rock bottom, and consists of grey ashy sand through which are interspersed three thin bands of clear sand weathered from the roof and walls, and layers of ash up to 2 in. thick, indicating discontinuous occupations of the site. The deposit is much disturbed by wombat burrows.

A trench 12 ft. long, 3 ft. wide and 2 ft. deep yielded the following Bondaian implements: four side scrapers on blades 3.4 to 4.4 cm., and one on a flake 2.3 cm., and five *Bondi* points from 1.8 to 2.6 cm. long. Implements are thus scantily represented in the deposit.

On the flatter portions of the back wall of this shelter is a frieze of 70 stencils which form several groups at the southern end and towards the middle of the shelter; some of them are just above the floor deposit, and as portion of these surfaces have weathered away it is probable that these lower-placed stencils were made before the shelter was occupied or before the deposit developed to any extent. The forearm is shown on several of the hand stencils. The stencils are as follows:—

Pale red human hands—right, 6.
Pale red human hands—left, 17.
Pale red human feet—6 in 3 pairs.

Dark red human hands—right, 5.
Dark red human hands—left, 8.
Dark red club—2. One 13 in. long, conical head 5 in. long.

Red hafted axe—One 13 in. long, with a big blade 8 x 7 in. in size.

Red boomerangs—Four from 26 to 29 in. long, curve shallow in relation to length, probably non-returning hunting boomerangs.

Red shields—Two 26 in. long.

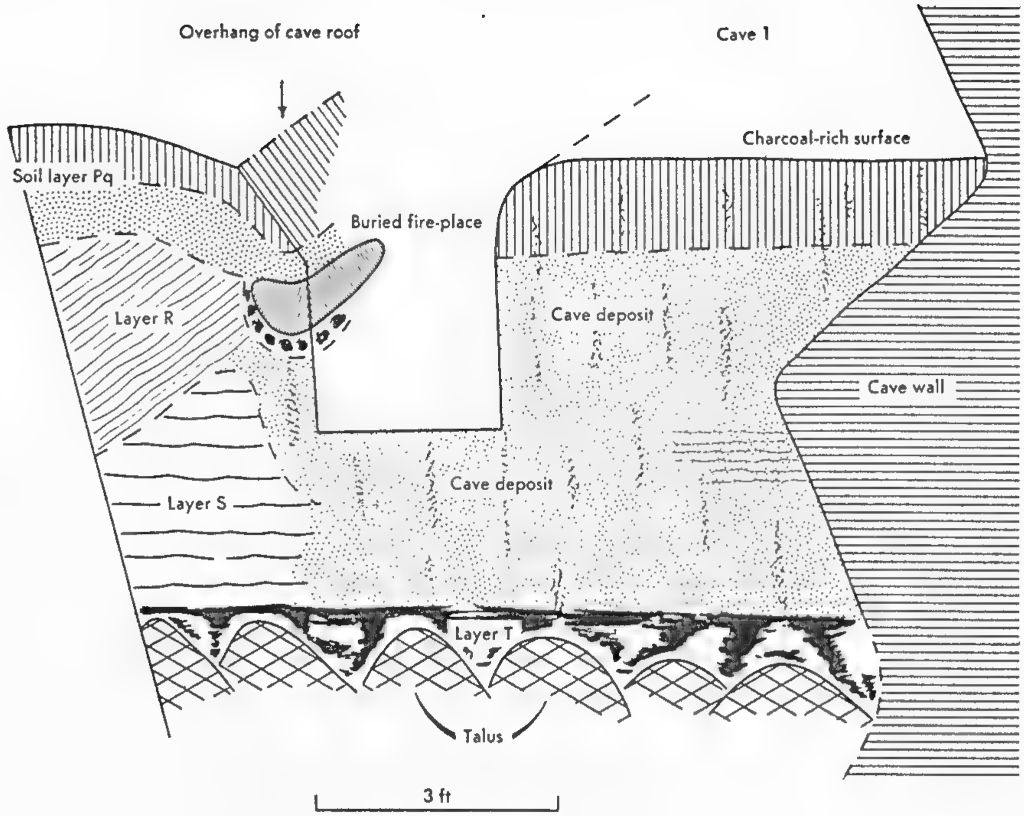
Red spear—1.

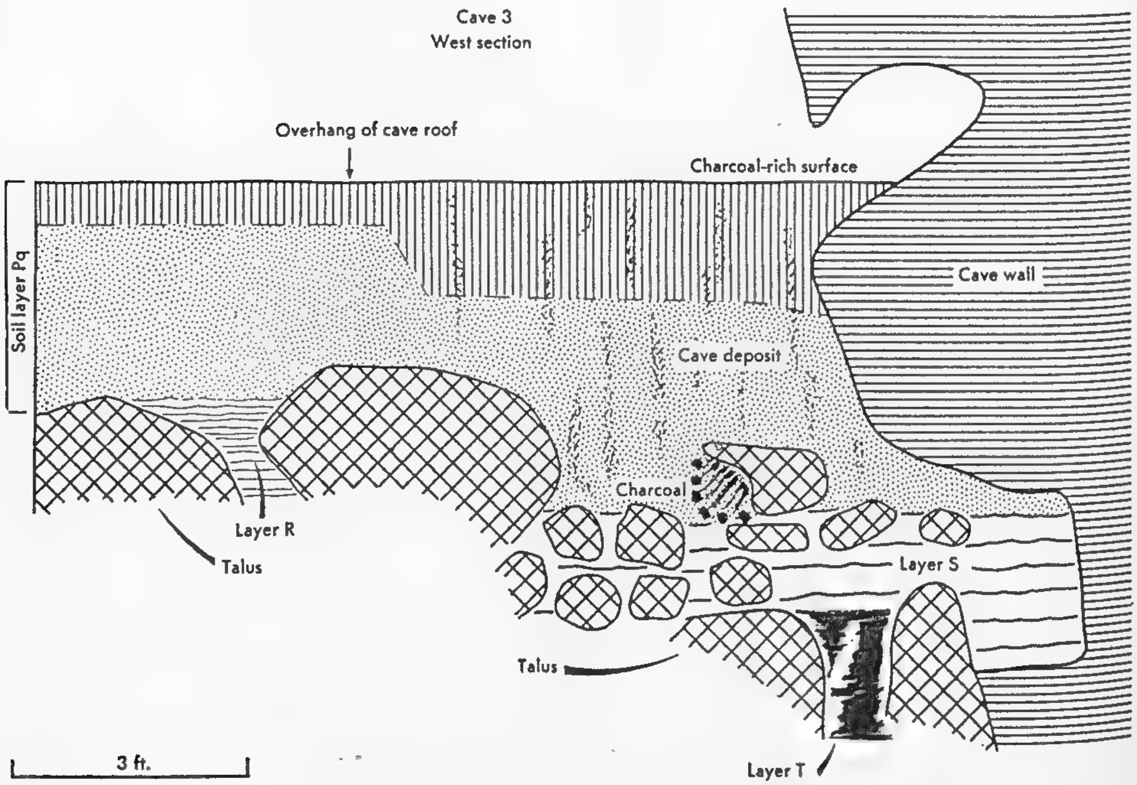
Red digging sticks—Two 26 and 31 in. long, 1 in. thick.

Red obscure figures—5.

White human hands—right, 4.
White human hands—left, 7.

At the northern end is a group of charcoal figures in which the interior of the body is infilled with closely drawn thick lines, which merge into solid areas on the limbs. These pseudo-silhouettes comprise a large figure, probably an anthropomorphic ancestral being or other spirit, 5 ft. 7 in. high and 2 ft. 4 in. wide, on which the lines are clearly visible down both sides but in the middle have been rubbed away by cattle sheltering in the cave; a human figure 3 ft. high; a koala 3 ft. high, and traces of three faded figures which include a fringe-like design 9 in. long.





Text Fig. 5.—In the upper diagram of the soils in site 1, the occurrence of stones is omitted except to illustrate the position of the talus boulders. The unconformities between soil layers are shown outside the cave, whilst inside the deposit has relatively homogeneous soil features. In the lower diagram, of the west section of site 3, the occurrence of stones is omitted except to show the presence of a stony layer just above the talus and the talus itself. A cave soil such as occurs in site 1 is evident towards the back of the section.

TABLE 3
Implement Frequencies

Implement	Site 1														Site 2	Site 3												Site 4	Site 5
	Bondaian						Capertian									Bondaian						Capertian							
	A	B	C	D	E	Totals	F	G	H	I	J	K	L	Totals		A	B	C	D	E-F	Totals	G	H	I	J	K	Totals		
	0-6	7-12	13-18	19-24	25-30		31-36	37-48	49-60	61-72	73-84	85-96	97-108		0-24	0-6	7-12	13-18	19-24	25-36		37-48	49-60	61-72	73-84	85-96		0-18	0-12
Ground Edge Axe	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	..	..	3	..	..	..	..	..	..	..	..
Ground Edge Axe Portion	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	2	..	..	3	..	..	..	..	..	..	..	..
1. Coroids—																													
Cores—1 platform	3	8	9	7	7	34	1	4	..	6	..	1	..	12	8	10	27	43	26	33	139	28	24	7	5	..	64	5	..
1 platform conical	..	..	..	..	5	5	..	..	..	..	1	..	..	1	..	..	..	2	1	..	3	..	1	..	..	..	1	..	..
2 platforms	..	7	7	2	2	18	..	2	2	2	1	..	..	7	5	3	11	32	19	11	76	4	4	4	1	..	13	3	..
2 platforms at angles	2	1	2	..	3	8	..	..	..	3	..	..	..	3	3	3	3	15	3	5	29	..	2	..	2	..	4	1	..
3 platforms	..	1	..	1	..	2	..	..	..	..	..	..	..	..	..	2	1	1	..	3	7	7	1	1	1	..	10	..	..
Alternate platforms	..	1	..	1	..	2	..	2	..	1	..	..	..	3	..	..	..	2	..	1	3	..	..	..	..	..	..	..	..
Irregular platforms	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	1	..	1	..	..	..	..	..	..	..	..
Remnants	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	2	4	9	..	..	..	..	..	..	..	..
Redirecting slivers	5	5	7	9	4	30	..	..	4	1	1	..	1	7	14	8	14	57	5	5	89	3	..	1	1	..	5	..	2
Redirecting blocks	4	3	4	4	5	20	..	1	1	..	..	..	..	2	2	..	1	..	4	..	5	4	2	3	..	..	9	..	..
Fabricators	1	2	..	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Burins—spalled	..	1	..	1	..	2	..	..	..	..	..	..	..	..	3	1	..	2	..	1	4	..	..	..	..	..	..	..	..
scaled	2	..	..	..	1	3	..	..	..	..	..	..	..	..	1	..	..	2	1	1	4	..	..	..	..	..	..	..	..
Coroids General	2	3	2	1	1	9	..	2	..	..	..	..	..	2	..	..	3	..	..	3	6	..	4	..	..	..	4	..	..
Uniface Pebble	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	2	..	..	..	7	..	..
2. Blocks—																													
General	1	3	3	1	1	9	..	2	..	..	..	..	..	2	7	3	2	10	10	7	32	4	17	4	3	..	28	1	..
Keeled	..	1	..	..	..	1	..	2	1	..	..	..	..	3	5	..	..	2	..	3	5	2	8	..	..	..	10	..	..
Worimi	..	..	1	2	1	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	2	..	..
3. Slices	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	1	1	4	2	..	..	..	..	2	..	..
4. Normal Flakes and Blades—																													
Elouera	2	..	2	..	..	4	..	..	..	..	..	..	..	..	1	1	2	2	1	1	7	..	..	..	..	..	..	..	..
Scrapers: Side	1	14	5	2	1	23	1	4	..	7	..	..	..	12	10	17	13	33	7	7	77	18	15	2	5	1	41	2	4
Side and end	..	1	..	..	..	1	..	..	..	2	..	..	..	2	2	1	5	2	1	1	10	4	..	1	..	..	5	..	..
Double side	1	..	..	..	2	3	..	..	1	..	..	..	..	1	5	6	4	5	1	1	17	6	1	..	..	..	7	2	..
Double side and end	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	1	1	..	3	..	..	..	..	..	..	..	..
Semi-discoid and discoid	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	1	1	1	1	10	3	1	..	..	..	4	..	..
Distal end	4	3	..	4	3	14	..	2	8	..	..	..	..	10	5	6	2	14	8	13	43	13	3	2	3	..	21	1	..
Butt end	2	1	2	1	1	7	..	..	..	..	..	..	..	..	..	1	2	5	2	4	14	..	..	..	..	..	..	1	..
Double end	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	3	4	7	..	4	..	..	..	4	..	..
Butt end notched	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lateral edge notched	..	7	..	2	..	9	..	2	..	..	..	..	..	2	1	4	6	5	..	5	20	4	..	..	1	..	5	..	..
Concave—lateral	2	..	2	2	4	10	3	3	3	12	..	..	..	21	7	7	2	6	5	12	32	18	14	6	1	..	39	1	..
Butt end	1	..	1	1	2	5	..	1	..	..	..	..	..	1	3	1	1	3	3	..	7	3	1	1	..	..	5	..	..
Distal end	1	2	..	..	..	3	..	3	1	..	..	..	..	4	..	6	5	3	..	4	18	5	3	1	1	..	10	..	..
Concave and nosed	2	..	4	7	2	15	..	4	4	5	2	..	..	15	9	..	3	..	11	10	24	30	36	5	2	..	73	1	..
Backed blades	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	..	..	..	3	..	..	..	..	..	..	..	..
Burin—spalled	3	1	4	2	2	12	..	..	1	..	..	..	..	1	3	2	2	5	2	1	12	..	..	..	..	..	..	..	..
scaled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
combined spalled and scaled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Knife	14	4	21	8	14	61	1	6	8	..	8	1	..	24	10	5	6	11	11	10	43	16	30	12	3	..	61	5	..
Saw	..	..	..	..	1	1	2	..	2	..	..	..	..	4	..	8	1	2	4	6	21	12	22	5	3	..	42	..	..
Fabricator—One end	1	1	..	..	..	2	..	..	..	..	..	..	..	..	3	3	10	1	..	..	14	2	3	1	..	..	6	..	..
Two ends	..	..	1	1	..	2	..	..	..	..	..	..	..	..	..	3	..	1	1	1	6	2	2	..	..	..	4	..	..
Lateral	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	2	3	..	..	5	2	2	..	..	..	4	..	..
Lateral and end	1	..	1	..	..	2	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Adze Slug—*Tula* type	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..
Adze Slug—*Burren* type	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..
5. Bondi Points	19	24	25	17	16	101	..	..	2	..	..	2	1	5	57	26	65	168	52	7	318	..	..	..	..	..	..	9	5
6. Microliths—																													
Geometric: Segment	..	1	3	..	1	5	..	..	..	..	..	..	..	..	3	3	5	7	3	1	19	1	..	..	..	..	1	..	..
Trapezoid	..	..	..	2	5	7	..	..	..	..	..	..	..	..	6	..	2	6	4	1	13	..	..	..	..	..	..	1	1
Triangle	1	..	1	..	..	2	..	..	..	..	..	..	..	..	1	..	3	3	..	1	7	..	..	..	..	..	..	..	..
Hat-shaped	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oblique trd.	2	..	2	1	..	5	..	..	..	..	..	..	..	..	2	2	2	2	1	3	10	..	..	..	..	..	..	..	..
Thumbnail	3	..	4	1	1	9	..	..	..	..	1	..	..	1	3	1	1	3	1	..	6	..	..	..	..	..	..	..	..
Discoid	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	1	..	5	..	..	..	..	..	..	..	..
Burins: Discoid spalled	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	1	2	2	..	..	5	..	..	..	..	..	..	..	..
scaled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Flake blade spalled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	2	..	..	..	..	..	..	..	..
scaled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	2	5	1	..	..	..	..	1	..	..
Combined spalled and scaled	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..
7. Percussion Stones—																													
Hammer—Pebble	..	..	2	..	..	2	..	..	..	1	..	..	..	1	..	..	1	..	..	1	2	1	3	..	..	..	4	1	..
Mortar	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..
						402								148							2,002						483	37	12

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The superimpositions are as follow: White hand over well preserved red hand; white hand over two well preserved dark red hands and shield; white hand over faded red hand; white hand (with three middle fingers together and separated from little finger) over red boomerang; red hands over faded red hands; red hands over two red boomerangs; dark red hand over red hand over red shield over red hand; black human figure over red hand; black koala over red hand. The sequence of colours, techniques and styles indicated is (1) stencilling in red was carried on for a long period; (2) white stencils are more recent than red stencils; black drawings are more recent than red stencils. The time relationship between the black drawings and the white stencils is not indicated in the superimpositions in this site.

The stencil of the hafted axe must have been made at or later than the middle of the Bondaian phase, when ground edge axes first appear in this area. There is no evidence in this site to indicate when stencilling ceased, or when the black drawings were made. As red and white, and black and white, phases of drawings succeeded the stencils in eastern New South Wales (McCarthy, 1962), it appears probable that the black drawings in this site were done in the Eloueran phase although implements of this phase do not occur in the floor. The shelter was thus occupied in the Bondaian phase, and visited in the Eloueran phase perhaps for ritual purposes.

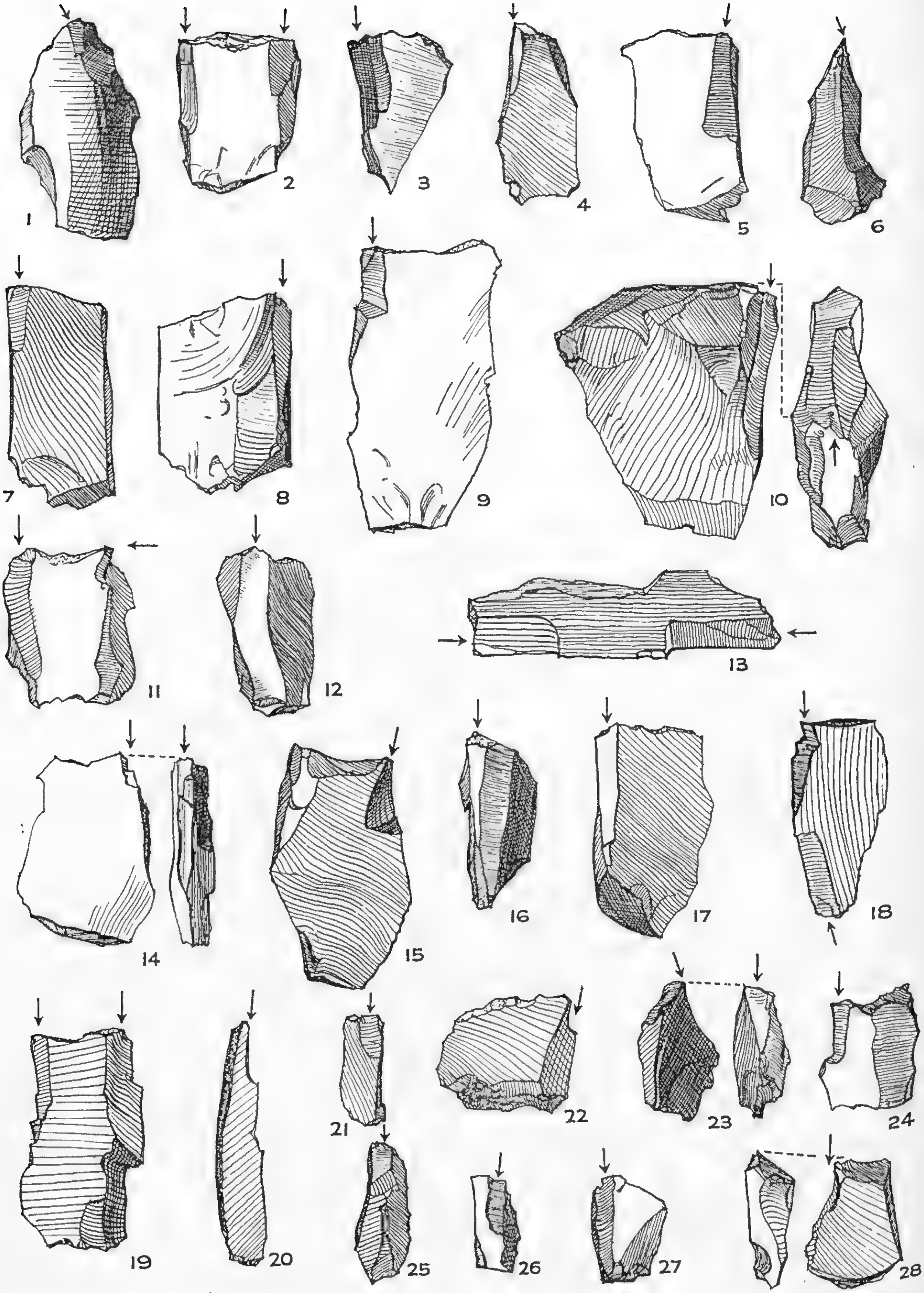
SITE 6

The Noola rock shelter was reported to me by Mr. N. Blunden in December, 1960. Stone implements, a charcoal sample and diagrams from a test trench dug by Mr. J. Bland, assisted by Mr. Blunden, for the Australian Museum, were sent to me in March, 1961. Mr. Bland reported that the deposit contained many layers of charcoal. It was then planned to excavate the site in December, 1961, but Mr. N. B. Tindale, Curator of Anthropology at the South Australian Museum, excavated the site in May. 1961, without consulting me and I had to abandon my plans to add this site to series 1 to 5 in my investigation of the archaeology of the Capertee Valley. Tindale published a paper (1961) on this site, which I have criticized (McCarthy, 1962, Tindale, 1962).

The shelter is 80 ft. long, 10 ft. high, 18 ft. from front to back, and is 300 ft. above the valley through which Bogee Nile Creek runs. It faces south across a terrace at the foot of a sandstone escarpment. On the eastern side is a spring of water about 80 yds. away. The test trench was 18 ft. long and 3 ft. wide. The deposit was only 9 to 12 in. deep for the first 9 ft., where it rested on a large slab of rock that had fallen from the roof, but it gradually deepened in the second 9 ft. The trench was taken out in 3-ft. squares and 6-in. layers to a depth of 5 ft. 10 in. only, and the end block, the deepest part of the deposit behind the fallen rock mass, was left undisturbed for the major excavation we planned but had to forego.

The following implements were recovered from the test trench of March, 1961:—

Layer 1, 0-6 in.: A secondary core, prismatic, with one dished platform, 4 cm. long, and a quartz core, 2.5 cm., with one flat platform; three punch-type fabricators, one double ended, 3.5 cm., with gouge working edges 1 and 1.8 cm. long, a small quartz one 1.5 cm. used on two adjoining edges, and one 2.2 cm. with working edge 8 mm. at one end; two side scrapers 2 and 3.2 cm., with convex edges; two side and end scrapers, one reverse trimmed, the other with a rounded nosed end and a pointed nose 4 x 2 mm. between very small concaves on the lateral margin; one double side scraper, 2.6 cm., reverse trimmed, and one 1.6 cm. trimmed on both sides of a pointed end.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Layer 2, 7-12 in.: A quartz core, 2.8 cm., with one dished platform, a black chert core, 3.2 cm., with one flat and one dished platforms, and two core remnants 1.7 and 2.3 cm.; two punch-type fabricators, 1.2 and 2.8 cm., one with working edges 7 mm. wide at both ends, the other with a gouge edge 2.5 cm. long at one end; a wide scraper 1.5 cm.; a segment 2.1 cm. heavily step chipped along the chord (like a small *elouera*); three *Bondi* points 1.3 to 2 cm.

Layer 3, 13-18 in.: One segment-shaped re-directing flake 2.3 cm.

Layer 4, 19-24 in.: A spalled burin of (*a*), central spalled, working edge 4 mm. wide, of quartz, and a flake, 4 cm., with a convex edge probably used as a knife.

Layer 5, 25-30 in.: A keeled discoid block, 5 cm. diameter, of quartz, with a series of 10 concaves from 3 x 1 to 15 x 3 mm., and seven noses from 3 x 2 to 2 x 1 mm., around the edge; and a quartz flake, 3.5 cm., with two concaves 10 x 3 and 13 x 3 mm. on one edge and two shallow concaves 7 x 1 and 7 x 2 mm. on the other margin.

Layer 6, 31-36 in.: No implements.

Layer 7, 37-42 in.: A core, 4.5 cm., of dark quartzite with two dished platforms at right angles; a quartz pebble, 5 cm., with flake scars at one end, probably a reject core; an outside spall flake, 4.5 cm., with a concave 14 x 3 mm. on one side, and a pointed flake, 3.2 cm., with a well-used concave 7 x 3 mm.

Layer 8, 43-48 in.: A double side scraper of quartz, 5.5 cm., reverse trimmed, with two concaves 10 x 2 and 10 x 3 mm., and a used convex edge, a quartz flake, 3.7 cm., with a rounded nose 7 x 3 mm. between concaves 7 x 2 and 10 x 2 mm.

Layer 9, 49-54 in.: A quartzite core, 4.9 cm., with one plain platform.

Layer 10, 55-60 in.: No implements.

Layer 11, 60-66 in.: A thin chert blade, 3.5 cm., with knife use on one long convex margin.

Thus, in the Noola trench, the specialized diagnostic implements were rare. Those found comprised fabricators in layers 1 and 2, a geometrical microlith and *Bondi* points in layer 2, to a depth of 12 in., and a burin in layer 4 (19-24 in.). In all other layers unspecialized cores, scrapers and knives were found.

A total of 3,084 implements were recovered from sites 1 to 5, and 35 from the test trench in site 6. In addition, some 1,500 waste flakes, blades and blocks were kept from sites 1 and 3, and a total count of section 9, site 3, revealed 283 implements to 2,237 unused pieces, indicating the richness of the sites.

←

Text Fig. 6.—*Burins. Macrolithic coroid type*: No. 1, single blow spalled (*g*); 2, concave scaled (*c*); 8, concave scaled (*e*); 10, combined scaled and single blow spalled; 11, rectangular triple spalled (*c*); 16, rectangular scaled (*c*); 19, combined spalled and scaled. *Macrolithic flake and blade:* 3, bevel spalled (*b*); 4, convex scaled (*d*); 5, rectangular scaled (*c*); 6, central spalled (*a*); 7, convex spalled (*d*); 9, rectangular scaled (*c*); 12, concave scaled (*e*); 13, combined spalled and scaled; 14, concave scaled, re-struck (*e*); 15, concave scaled (*e*); 17, concave scaled (*e*); 18, convex scaled (*d*); 20, convex scaled (*d*), a *Bondi* point with re-struck burin edge. *Microlithic burins: Flake and blade:* 21, rectangular scaled (*c*); 22, convex scaled (*d*); 23, convex scaled (*d*); 24, concave scaled (*e*); 28, counter scaled (*f*). *Coroid:* 25, single blow spalled (*g*), tabular shape; 26, bevel spalled (*b*); 27, combined spalled and scaled.

COMMENTS ON THE IMPLEMENTS

Bondaian Phase in All Sites

The cores with one striking platform are predominant, and those with two platforms, including prismatic types, are well represented. Conical cores, and those with alternate platforms, are extremely rare. Re-directing slivers and blocks are plentiful, indicating employment of a knapping technique in which the core platforms and working were well controlled.

The coroid implements and blocks are mostly unspecialized, and there are only four *worimi* blocks, all from site 1. Slices were found in sites 2 and 3 and are of minor interest in the assemblage.

A small number of *elouera* occur in sites 1 to 3 and they are limited to the Bondaian phase layers. Backed blades apart from *Bondi* points are rare.

Side scrapers are by far the commonest type in this group followed by the end, concave, concave and nosed working edges. It will be noted that the butt and double ended scrapers are unusually well represented. In the table every flake or blade with a concave working edge has been classified in this group to stress the importance, as I have pointed out previously (McCarthy, 1943 a-e, 1946, 1947, 1948, McCarthy and Setzler, 1960), of this working edge in Australian lithic industries.

Knives, defined as all flakes and blades with a use-fretted or delicately trimmed edge, are well represented in all sites but there is no specialized type among them.

The dentated saw edge is present in all layers of site 3, but did not occur in sites 2, 4 or 5 at all, while only one in layer 5 was found in site 1. It is thus comparatively rare in the Bondaian phase.

Flake fabricators, mostly of the punch or bipolar knapped type, are best represented in sites 2 and 3. They are limited to the Bondaian in site 1, and none were found in sites 4 and 5.

Only two worked-out slugs occurred in the sites as a whole, from sites 3 and 4. Their appearance in the top of the Bondaian phase indicates that the wearing down of hafted adze flakes to a slug was a comparatively late development in eastern New South Wales, and their scarcity suggests that this was not a common practice in the area. It also indicates that the differential diffusion of this practice in time and space on the vast continent of Australia will cause some reversals of stratification of specialized types of implements.

The *Bondi* points occur in large numbers in all sites, as the total of 318 from site 3, 111 from 1, 57 from 2, 9 from 4 and 5 from 5 indicate. They include all of the variations of shape, nature of butt, and extent of characteristic of this point (McCarthy, 1946). They grade into the microlithic segment in these sites. There is no evidence

TABLE 4

Sizes of Concave and Nosed Working Edges

Mm.	Bond	Cap.
2 x 1	..	2
2	2	3
3 x 1	3	1
2	5	4
4 x 1	3	2
2	7	9
5 x 1	7	3
2	23	21
3	5	2
6 x 1	2	2
2	15	7
3	..	1
7 x 1	1	7
2	19	24
3	5	8
8 x 1	7	1
2	8	6
3	1	4
4	..	1
9 x 1	1	..
3	2	..
7	1	1
10 x 1	9	6
2	42	38
3	10	18
4	2	5
11 x 2	2	..
3	3	..
12 x 2	9	8
3	2	2
4	3	1
13 x 1	..	1
2	3	9
3	2	3
4	1	2

Mm.	Bond.	Cap.
13 x 5	1	2
14 x 2	2	..
3	1	..
4	1	..
15 x 2	10	16
3	7	9
4	4	2
5	1	1
16 x 3	..	1
17 x 1	1	..
..	..	..
3	1	1
18 x 2	1	1
3	1	2
5	2	..
20 x 2	4	1
3	1	5
4	3	1
5	1	3
6	1	..
23 x 2	..	1
4	1	..
24 x 2	1	..
25 x 1	..	1
2	3	...
3	2	1
4	2	..
5	1	2
26 x 2	..	1
30 x 2	1	1
3	1	..
5	1	..
6	1	..
8	1	1
35 x 4	1	..

Mm.	Bond.	Cap.
35 x 5	1	1
36 x 2	1	..
40 x 1	..	1

Mm.	Bond.	Cap.
2 x 1	..	2
2	2	..
3 x 2	5	14
3	2	..
4 x 1	1	..
2	3	4
3	2	5
5 x 2	7	10
3	4	1
4	..	6
5	2	2
6 x 2	3	4
3	3	1
4	..	1
7 x 2	..	3
3	4	6
4	..	4
5	3	4
7	2	..
8 x 2	3	..
3	2	2
4	1	1
5	1	4
8	1	1
9 x 5	2	..
10 x 2	5	1
3	3	4
4	3	9
5	4	8
6	..	2
7	..	3
8	..	1
12 x 2	2	..
3	2	2
4	..	3

Mm.	Bond.	Cap.
12 x 5	..	4
13 x 2	..	2
4	..	1
5	1	2
7	..	1
14 x 7	1	..
15 x 2	1	..
4	4	1
5	1	6
6	..	1
7	1	..
17 x 2	..	1
6	1	..
10	..	1
20 x 2	..	..
4	..	1
6	..	1
7	1	..
8	..	1
24 x 8	..	1
25 x 2	1	..
..	..	..

The above analysis of concaves demonstrates that the great majority are 2 mm. deep, and that the commonest widths are 4 to 5, 7, 10 and 15 mm., with limits of 2 x 1 to 35 x 5 mm. These concaves would thus fit the spear and club shafts. The sizes of the trimmed noses show that the small 2 x 2 to 8 x 5 mm. are predominant, the 10 x 2 (-8) mm. sizes are common, and the limits are 2 x 1 to 24 × 8 mm.

to support Mitchell's claim (1961) that the *Bondi* point is a discarded scraper implement. Many are yellow patinated.

TABLE 5

Characteristics of Bondi Points

	Site				
	1	2	3	4	5
Left side trimmed	64	34	168	6	5
Right side trimmed	42	21	151	3	2
1 edge side trimmed	73	27	163	5	..
2 edges side trimmed	43	30	152	4	5
Butt—plain	51	23	81	4	4
do faceted	5	4	9	..	..
do Trimmed-pointed	11	7	41	1	..
do round	28	17	90	2	..
do straight	1	..	6	1	1
do oblique	..	..	1	..	..
do concave	1	..	..	1	..
do broken	11	7	23	..	..
Point broken	25	6	60	3	..
Partly trimmed	24	13	49	..	1

The left side trimmed points predominate over the right, the one and two edge trimmed types are equal, there is a low number of faceted butts, a high number of plain butts and of those trimmed to a pointed or rounded end. Other kinds of butts are rare, but partly trimmed points are common, most of them being trimmed at the point end, or the point and butt ends, and rarely at the butt end alone. Broken points are common as in other sites.

The geometric microliths, of which there are 39 from site 3, 10 from 3, 1 from 4 and 1 from 5, display a wide range of variation in the basic forms of segment, trapezoid and triangle represented, only one other, a hat-shape or very long segment, occurring. Oblique trimmed blades and thumbnail scrapers are well represented but discoids are rare. There is no evidence to support Mitchell's claim (1961) that the geometrics are discarded scraper implements.

Burins are particularly well represented in these sites, no less than 89 having been recovered, the largest series yet described in Australia. The dominant types are the spalled and scaled as in other eastern New South Wales sites (McCarthy, 1943 a-c, 1946, 1948) in the coroid, normal flake and blade and microlithic groups. The bec-de-flute burin is rare, and fluted burins are absent. Eleven of the burins described were sent to Dr. Miles C. Burkitt, in Cambridge, England, who accepted them as burins, and consultations were held with Mrs. T. Belleau-Kemp, now of Sydney, and Messrs. R. V. S. Wright and V. Megaw, University of Sydney, before the final selection was made. Although the same technique is employed on the cores for knapping the blades for making *Bondi* points, and some difficulty is involved in distinguishing cores

(especially of the prismatic type) from burins in the Bondaian culture, it should be pointed out that the burin spall is much thinner than the point blade, and on the burins many of the spalls do not run their full length; these two characteristics help to separate burins and cores. An examination of western New South Wales implements in the Museum's collection revealed an equally wide range of spalled and scaled burins in an industry in which the *Bondi* point does not occur, and on sites from localities in which the symmetrical *Pirri* point is extremely rare. The presence of burins in such large numbers throughout the Bondaian culture suggests a special usage for the implement, probably for incising designs on wooden weapons and implements.

The ground edge axe, of which three complete and three fragments (all bearing grinding) were recovered between 13 and 18 inches in site 3, represents the first appearance of edge grinding in eastern New South Wales. The pebble, flaked pebble and biface coroid types found are also three of the earliest axe types developed in Australia.

The percussion and abrading stones are poorly represented, which is a somewhat surprising result in view of the occurrence of a number of plant foods, prepared with these implements, in the valley, and also the rich stone industries in the sites.

As an awl and a broad pointed implement from site 4 were the only bone tools found in all sites, it is concluded that implements made of this material were of minor importance to the Capertee Valley natives.

The Bondaian phase is thus seen to be a much richer assemblage in the Capertee Valley, on the western side of the Blue Mountains, than at Lapstone Creek, on the eastern side. The addition of the ground edge axe, gum hafting, geometric microliths, saws, the abundance of burins and of bone fragments, widen the range of types and food resources recorded for this period. The tables of implements at the two sites reveal a very close agreement in the range and frequencies of types, in the abundance of cores with one and two platforms, redirecting flakes, side, end, concave and nosed scrapers, simple knives, burins, *Bondi* points and microlithic-sized implements, and in the scarcity of blocks, slices, *elouera* and use-polished edges.

Capertian Phase in All Sites

This phase was found only in sites 1 and 3, below the Bondaian phase.

The cores with one striking platform are the commonest, although those with two and three platforms are well represented. Re-directing slivers and blocks are present but not in as high a proportion to the cores as in the Bondaian phase.

Coroids are scarce, the outstanding type being the uniface pebble implements of which seven were found in site 3. Several of them are typical Kartan culture types as found on Kangaroo Island in South Australia (Cooper, 1943, 1960) and elsewhere in South Australia (Cooper 1959, 1961). Their presence between 37 and 60 inches (prior to the introduction of the ground edge axe in the Bondaian phase) indicates chopper use as shown by the battered working edge of one in particular. It is also in accord with their stratification in south-east Asia (van Heekeren, 1957) and central New Guinea (Susan Bulmer, 1961).

Blocks of all sizes occur in this assemblage, but two of *worimi*-type are the only specialized forms.

Side and distal end scrapers and the concave and nosed varieties predominate among the scrapers.

Simple knives, with use-fretted or delicately trimmed edges but of no particular types, are common and probably served as flesh cutters.

An outstanding feature of the Capertian is the saw with a carefully dentated edge. The dentations occur on concave, straight and convex edges, or on two of these combined on the one implement. The length of the saw edge varies from 1 to 5.5 cm., the short edge being more common, and their use cannot be conjectured apart from that of cutting. It was always believed that this edge was a comparatively late introduction into the Kimberleys of north-west Australia, whence it was thought to have diffused into the interior. It is widespread on surface camp-sites throughout western New South Wales, western Queensland, and westward across the continent. The discovery of this edge, however, in the Capertian proves quite clearly that its use goes back to our earliest industries.

Fabricators were used in this phase, but they are rare.

Five *Bondi* points were found in layer H, 49 to 60 in., layer K, 85 to 96 in., and layer L, 97 to 108 in., and a geometric microlith in layer G, 49 to 60 in., in site 3. The faunal cavities up to $\frac{3}{4}$ in. in diameter would appear to account for these tiny implements working their way down to such depths.

Four pebble hammerstones found in site 3 and site 1 establish this as the common type of percussion stone.

Comparison of Bondaian and Capertian Phases

The basic series of large primary flakes and blades, roughly chipped on the most suitable edge, on which concaves are also common, were used throughout both phases, but they are more abundant in the Capertian, in which they form the principal series of tools, than in the Bondaian. The trimmed nose is common to both phases with a very large number of them between 37 and 60 in. in site 3. Fabricators and simple knives are characteristic of both phases.

The cores, blocks and trimmed coroids show very little variation in both phases as they are mostly unspecialized forms, and the *worimi* is scarce in all of the sites. A few uniface pebble implements, however, are present in the Capertian but not in the Bondaian.

Although burins occur in both periods, they are in markedly greater numbers in the Bondaian, while the reverse is true for the saws which occur in greater numbers in the Capertian. The two adze slugs found both belong to the late Bondaian. Thus the presence of slugs, gum hafting and burins in the Bondaian indicates that a change in wood working and carving techniques took place in this phase.

Thirty-nine out of 407 Bondaian implements and 7 out of 147 Capertian implements in site 1, in which there were 56 out of 116 *Bondi* points, are of microlithic size, to which are to be added 29 geometrics; 138 out of 1,194 Bondaian implements, 46 out of 483 Capertian implements in site 3, which had 166 out of 318 *Bondi* points, are of microlithic size, to which are to be added 65 geometrics. The implements from these sites are thus bigger on the average than those at Lapstone Creek.

The two phases illustrate the history of stone working in eastern New South Wales from an early period of primary flakes, saws and uniface pebble choppers to a later period of elegant *Bondi* points, microlithic implements, the hafting of specialized and unspecialized types, and the appearance of the ground edge axe.

The later period, the Eloueran, which succeeded the Bondaian at Lapstone Creek (McCarthy, 1948), was not present in these Capertee Valley sites.

In considering the affinities of the two phases, it should be pointed out that as the saws of the Capertian and slugs of the Bondaian both came from the west, the Capertian could well be the industry that preceded the Tula culture (McCarthy, 1962 a-b) in the interior of the continent. For this reason I would link the Capertian with the Gambieran of the Coorong in south-east South Australia, an industry of great importance which Tindale (1957 a-b) has attributed wrongly to the Tartangan. The Tasmanoid affinities of the Capertian lie mainly in the occurrence of the trimmed nose, often multiple, on Clactonian-type primary flakes and blades, and a few long-edged side scrapers, but this industry is, on the whole, much cruder than both the Gambieran and Tasmanian. Dentated saws do not occur in Tasmania.

The introduction into the Capertee area of the *Bondi* point, geometric microliths, *elouera*, gum hafting, the elaboration of the burin and later the introduction of the ground edge axe, and the working back of adzes into discarded slugs, indicates contact with an important stream of culture diffusion whose direction is not as yet known. The points and the axe appeared abruptly at Lapstone Creek (McCarthy, 1948), and as both are known in northern New South Wales, and the point is not found in far western New South Wales, they would appear to have come from the north I prefer to regard these changes as being due to diffusion rather than to new waves of Aboriginal people.

Notes On the Unused Flakes

In the Bondaian phase most of the flakes have been struck from light-grey chert, but the cherts include blackish-grey, pink, and laminated kinds. Chert outcrops in horizontal Permian beds, which break up into flat-sided lumps, below the Triassic sandstones in various parts of the Capertee Valley. Grey and red quartzites, and quartz, are also present. A few complete, and some broken, pebbles of quartz, chert and quartzite were recovered together with flat-sided lumps of chert.

The majority of the unused flakes are irregular in shape, with a low percentage of well shaped blades. Blades and flakes with long edges are well represented but they are not of any standard pattern. Some are larger slices from 6 to 13 cm. long. The majority are yellow-stained and patinated, but those from the top grey ashy-sand part of the deposit, and from fireplaces, are grey-stained.

The diffused bulb is common, there being less than 100 with salient bulb among the hundreds retained. Fifty have a faceted butt which is more typical of this Bondaian phase than of the Capertian. A low percentage only have a bulb platform on which the angle could be measured.

The same range of materials was used in the Capertian phase. Blocks and lumps of local chert up to 13.5 cm. long, and of basalt and quartz up to 5.5 cm., slices from 8 x 6 to 9 x 9 cm., and blades from 6 to 11 cm., together with numerous fragments of quartz, a smooth water-worn pebble 7 cm., many large lumps of a soft red quartzite, and several flakes of a hard, glassy, grey quartzite, were found in these lower layers. Most of these pieces are yellow-stained and patinated, but in the fire-pit in section 8 to 12 grey-stained pieces were found. In the deeper layers some pieces bear a thick dark-orange patination. Forty-eight pieces bear a salient bulb, but there is also a low percentage of measurable angles in this phase. No faceted butts are present. The chert is suitable for use only as a freshly flaked edge, and it softens after detachment and exposure.

Technique

Although a Clactonian technique was employed mainly in knapping flakes and blades in the Capertian phase, and percussion trimming was used on the working edges of the blocks, slices and scrapers, it is well to note that pressure chipping was used in making the neatly dentated saws. Diffused bulbs are predimonant, and the faceted butt is unrepresented in this phase.

In the Bondaian phase the faceted core platform of the Levallois technique came into operation and is shown commonly on *Bondi* points and scrapers, and this might be said to be the only important addition to the knapping technique. Pressure trimming was additionally practised in shaping the *Bondi* points and the geometric microliths.

The table of butt angles suggests that there was an emphasis on a slightly higher angled butt platform in the Capertian than in the Bondaian phase. In the former the emphasis lies between 115 and 130 degrees, after which it drops suddenly to a peak at 142 degrees. In the Bondaian the main emphasis lies between 105 and 125 degrees, with a gradual drop away at each end to limits of 85 and 145 degrees. There is thus a complete agreement in techniques with the Lapstone Creek Bondaian period.

A complete count of waste flakes to implements was made in section 9 of site 3, with the following result:—

	Impls.	Flakes	Bone	Shell
Layer 1, 0-6 in.	68	1,240	19	8
2, 7-12	20	350	..	..
3, 13-18	72	536	2	..
4, 19-24	15	128	..	..
5, 25-36	24	360	..	..
6, 37-48	19	151	..	..
7, 49-60	41	397	..	..
8, 61-72	24	175	..	..
	283	2,237	21	8

There is thus a fairly consistent pattern and proportion of implements to waste flakes in the various parts of the deposit with the exception of layer 1. This was a section of yellow gritty sand from top to bottom and all of the implements and flakes are yellow-stained and patinated.

The faceted butt (of advanced Levallois type) ranges from 90 to 100 to 120 degrees in site 1, and from 85 to 90 to 117 in site 3, and is thus generally lower than the plain Clactonian butt angle. The *Bondi* point butt angles range from 90 to 118 with no peak, and fit in precisely with the angles of the blocks, slices and scraper, excluding all faceted butts in both cases. It is worth mentioning that a relatively low proportion of flakes and other knapped implements have butt platforms on which the angle could be measured, due to the use of laminated chert for many implements and to the knapping of flakes and blades haphazardly from the cores.

FAUNA

Site 3 yielded a considerable quantity of bone so broken up into fragments that it would serve no useful purpose to tabulate the number of pieces in each layer. There are very few complete bones, and they are small ones, all of the long bones having been split up, apparently to get the marrow, and, likewise, there are no complete mammal skulls as these were probably disarticulated to get the brain. Thirty-five mammal mandibles, and several lizard mandibles, were obtained from site 3, in which bone material was plentiful down to 36 in., scanty from 37 to 48 in., and absent between this depth and the bottom of the deposit at 84 in. Sites 1, 2 and 4 yielded a small quantity of broken bones which included two mandibles in site 2, and a quantity of fresh and well preserved bones which included seven mandibles in the top layer of site 4. No bird or fish bones are represented in any of the sites.

All of the bones belong to living species of animals, identified from the mandibles as follows:—

Site 3, *layer A*, 0-6 *in.*: *Trichosurus vulpecula* (Brush-tailed Possum), section 6; *Petaurus* sp. (Glider Possum), sect. 4; *Pseudochirus peregrinus* (Ring-tailed Possum), sects. 8-9; *Isoodon* sp. (Short-nosed Bandicoot), sect. 8; *Wallabia bicolor* (Swamp Wallaby), sect. 8.

Layer B, 7-12 *in.*: *Trichosurus vulpecula*, sect. 6; *Wallabia bicolor*, sect. 9.

Layer C, 13-18 *in.*: *Trichosurus vulpecula*, sect. 6; *Wallabia bicolor*, sects. 5, 6, 7, 8, 9; *Wallabia* sp. sect. 7; *Petrogale penicillata* (Rock Wallaby) sect. 6; *Isoodon* sp., sects. 7, 8.

Layer D, 19-24 *in.*: *Trichosurus vulpecula*, sect. 6; *Wallabia bicolor*, sect. 6, 11; *Pseudochirus peregrinus*, sect. 7; *Phascolomis mitchelli* (wombat), sect. 7; *Canis familiaris* (dingo), sect. 6.

Layer E, 25-36 *in.*: *Trichosurus vulpecula*, sect. 7; *Wallabia bicolor*, sect. 6, 7; *Wallabia* sp., sect. 4; *Isoodon* sp., sect. 6; *Pseudochirus peregrinus*, sect. 7.

Layer F, 37-48 *in.*: *Wallabia* sp., sect. 7.

Layer G, 49-60 *in.*: *Wallabia bicolor*, sect. 6; *Wallabia* sp., 6, 8; *Physignathus lesueurii* (Water Dragon), sect. 8.

Site 2 yielded mandibles of *Wallabia bicolor* and *Wallabia* sp. and one of *Trichosurus vulpecula*, and site 4 produced *Wallabia bicolor*, *Trichosurus vulpecula* and *Pseudochirus peregrinus*.

It is considered probable that the *Wallabia* sp. is *bicolor*, the material being insufficient to permit of a precise identification of the species.

It will be noted that eight kinds of mammals, and one species of lizard, are represented, among which the Swamp Wallaby, Brush-tailed and Ring-tailed Possums are the commonest, and as they both occur consistently through the layers containing bones it would appear that the principal flesh food of the inhabitants of the sites was obtained from these animals and that their economy was adapted to hunting them. Possums supplied meat, pelts for skin cloaks in the winter, and mandibles for tools, and were an important game in eastern New South Wales (McCarthy, 1957).

Notable absentees in the above list are the Big Grey or Forester Kangaroo, and the koala, both of which live in this valley, and the emu, which inhabited the wider part of the valley, above the junction of the Capertee and Running Stream. Whether it lived on the broader flats of the gorge in which the rock shelters are situated is

not known. Fragments of emu shells occurred in several layers of our trench in site 6, but none were found in sites 1 to 4 in the gorge, or in site 5. This would also indicate that the inhabitants of the gorge did not hunt in the wide upper part of the valley. The site 6 test trench yielded mandibles of *Trichosurus vulpecula*, *Wallabia* sp., *Macropus* sp., *Pseudochirus peregrinus*, *Phascolomis mitchelli*, and the moveable finger of a crayfish. Thus the Noola people added the emu and its eggs and the big grey kangaroo to their diet.

Eels, perch and crayfish inhabit the Capertee River but no fish bones occurred in sites 1 to 4. Mussels were collected from the river but not in great quantity as they may not have been abundant. Fragments of mussel shells occur to a depth of 30 in. in sites 1 and 3, but they were scattered through the deposit and did not occur in thick layers or batches. It is most probable that fish and crayfish were also eaten.

ACKNOWLEDGEMENTS

In addition to the many individuals who worked so hard to ensure the success of the excavations, my sincere thanks are due to the Division of Soils, Commonwealth Scientific and Industrial Research Organization, for its valued co-operation in permitting Mr. P. H. Walker, M.A., to investigate the composition and development of the archaeological deposits, and also for granting permission for me to use figures 2, 4-5 in this paper; the University of Sydney Rover Scout Crew for its sustained support of the field work, in which the discipline and efficiency of its members were deeply appreciated over a period of two years; Professors A. P. Elkin, M.A., Ph.D., and N. W. G. Macintosh, M.B., B.S., and Mr. R. V. S. Wright, M.A., of the University of Sydney; Mr. J. Golson, M.A., Australian National University, and Mrs. T. Belleau-Kemp, who read the manuscript and made many helpful suggestions about its presentation; Mr. B. J. Marlow, B.Sc., Australian Museum, and Professor R. G. Stirton, University of California, for identifying mammals, and Mr. H. G. Cogger, M.Sc., Australian Museum, for identifying lizards, from the bone material obtained; and the following members of the staff of the Australian Museum: Mr. R. O. Chalmers, A.S.T.C., for identifying stone materials; Mr. H. Hughes, for photographs of the implements in plates 2-14; Mr. D. Rae, for the drawings of burins in figure 6, and Mrs. E. Brown for figure 3.

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EXPLANATION OF PLATES

Plate 11.—Fig. 1: Site 1. Fig. 2: Site 3. *Macrozamia* palms in foreground. Fig. 3: Site 2. Fig. 4: The deposit in site 5, showing thin bands of clean sand accumulated from the cave roof during periods of non-occupation. Fig. 5: The west section of site 3, showing the large boulders of the underlying talus on left, and the boulder layer, to which scattered boulders found in the deposit had been added, on the right. Fig. 6: Average yield of flakes and implements from sieve in Bondaian layers of site 3.—Photos: Author.

Plate 12.—Fig. 1: Site 3, showing the height to which it was filled up to leave a small shelter at the end of Aboriginal occupation. Fig. 2: Portion of the working party on site 3. Fig. 3: As site 3 was excavated it was revealed to have been formed by a series of small cavities one above the other within the main cave. Fig. 4: The dark lines on the section exposed in the deposit mark the extent of the large ashy-grey fireplace area which extended to a depth of 54 in. Fig. 5: Fireplace in section 8 of site 3. Fig. 6: The wall of the deposit in the north-east corner of site 3 section 9, showing the ashy-grey layer at the top contrasting with the buff coloured deposit below, in which scattered boulders are visible.—Photos: Author.

Plate 13. Capertian, Site 1.—Fig. 1: Slice with notched edge. 2: Blade with notched edge. 3: Knife. 4: Notched side scraper. 5: Flat slab of chert used as scraper on one edge. 6: Scraper with well-used concaves on both lateral margins. 7: Flake with two rounded noses between concaves. 8: Notched end scraper. 9: *Elouera*-like segment. 10: Blade with unusually long trimmed nose, like a borer, between concaves on the distal end. 11: End scraper. 12: Double side scraper. 13: Saw. 14: Concave on end of quartz spall. 15: Concave and nosed scraper. 16: Keeled end scraper. 17: Keeled block with trimmed convex distal end. 18: Keeled end scraper with notched edge. 19: Concave and nosed block. 20: Small block with prominent pointed nose.

Plate 14, Bondaian, Site 1.—Fig. 1: Double side and end scraper, with an orange patination on outer and inner surfaces, a dark-grey and white patination on the trimmed edges. 2: Notched blade. 3: Scraper with rounded nose between concaves. 4: Scraper with small rounded nose between concaves. 5: Butt end concave and nosed scraper. 6-8: *Elouera*. 9: Double side scraper with pointed nose between concaves. 10: Side and end scraper. 11: Double side scraper, with concave. 12: Narrow thin blade with light trimming on one lateral margin, and a concave on the other, reverse-trimmed. 13: Concave side scraper. 14: Pointed blade lightly used as knife on both lateral margins. 15: End scraper. 16: Notched block of microlithic size. 17: *Glanmire*-type butt end scraper. 18: Side scraper. 19: Concave and nosed scraper. 20: Double side scraper, reverse trimmed, with concave working edge. 21: Coroid fabricator, discoid in shape and biface worked, used all round edge. 22: Side scraper. 23: Side and end scraper. 24-6: Fabricators.

Plate 15, Bondaian, Site 1.—Fig. 1: Two rows of *Bondi* points, showing variation in shape, length and trimming. 2: Two rows of geometric microliths including trapezoids, segments and triangles. 3-8: Oblique trimmed blades. 9-10: Backed blades. 11: *Elouera* lightly used on chord. 12: Narrow segment. 13: Double end scraper. 14-16: Thumbnail end scrapers. 17: (left) *Burren* adze slug. 17-20: Microlithic scrapers.

Plate 16, Bondaian, Sites 1 and 2.—Figs. 1-3: Keeled blocks well-used on both lateral margins and distal end. 4: Block, reverse trimmed, used on both lateral margins and end. 5: Block with notched working edge. 6: Alternately knapped core. 7: Pebble used as a hammerstone and mortar (on surface not shown). 8: Pebble used as hammer and anvil. 9: Pebble core with dished platform at one end.

Plate 17, Bondaian and Capertian Cores, Site 1.—Fig. 1: Slab of laminated chert with oblique working edge. 2: Uniface pebble implement heavily used on both ends and lateral margin. 3: Prismatic core with flat platforms at both ends. 4: Core used as scraper on both ends. 5: Re-directing flake with long, very neatly trimmed edge. 6: Core with dished and cortex platforms at right angles. 7: Core with dished platform at one end and a flat platform at the other end. 8: Prismatic core with dished platform at one end. 9: Conical core with dished platform at one end. 10: Core with two flat cortex platforms at right angles.

Plate 18, Capertian, Site 3.—Fig. 1: Large conical core, with dished platform. 2: Uniface pebble implement with working edge extending round both ends and lateral margin. 3: Conical core with flat platform. 4: Uniface pebble implement with oblique working edge across middle. 5: Core with dished platforms at both ends. 6: *Worimi* chopper heavily stained with manganese. 7: Core with one dished platform.

Plate 19, Capertian, Site 3.—Figs. 1-2, 4, 6, 8: Concave and nosed scrapers of Tasmanoid type. They bear from one to four noses between concaves on comparatively big flakes. 3: Blade with lightly trimmed edge, probably used as a knife. 5: Thick blade with notched edge. 7: Block with concave working edge. 9: Large flake with bi-faceted working edge similar so that of a fabricator. 10: Large flake with knife use on chord. 11: Blade with notched edges. 12-13: Side scrapers with notched edges. 14: Block with concave and nosed edge.

Plate 20, Capertian, Site 3.—Fig. 1: Concave and nosed scraper. 2: Concave and nosed block. 3: Concave and nosed double side and end scraper. 4: Concave and nosed scraper. 5: Side scraper with convex working edge. 6: Side scraper with well-used concave. 7: Semi-discoid scraper. 8: Side and end scraper. 9: Double side and end scraper with pointed noses between concaves. 10: End scraper (projection not used). 11: Quartz implement heavily used on one lateral margin, like a slug. 12: Concave side scraper. 13: Butt end scraper with two concaves. 14: Concave side scraper. 15-16, 18-24: Saws showing variety of blades and flakes bearing a dentated edge on convex, straight and concave margins. 17: Nosed end scraper.

Plate 21, Bondaian, Site 3.—Fig. 1: Ground edge axe, flaked pebble type. 2: Ground edge axe, pebble type. 3: Quartz hammerstone. 4: Slice with trimmed convex distal end. 5: Ground edge axe, biface coroid type. 6: Block trimmed all round both lateral margins and one end.

Plate 22, Bondaian, Site 3.—Figs. 1-7: Blades and flakes with long trimmed working edges, some of which bear concaves. 8: Nosed scraper. 9: Notched scraper. 10: Side and end scraper. 11: Reverse trimmed side and end scraper. with two concaves. 12: Large *elouera*. 13: Double side and end scraper. 14: *Elouera*. 15: Flat chert side and end scraper. 16: Notched scraper. 17: Side and end scraper, reverse trimmed. 18: Microlithic *elouera* or segment, heavily used on chord. 19: *Elouera*, well-used on chord.

Plate 23, Bondaian, Site 3.—Fig. 1: Core with one flat cortex platform. 2: Microlithic prismatic core with platforms at right angles. 3: Prismatic core with platforms at both ends. 4: Core with one dished platform. 5: Small prismatic core with platforms at both ends. 6: Conical core with one dished platform. 7: Side and end scrapers. 8: Pebble hammerstone. 9: Side scraper, bearing portions of beeswax hafting, used as a flake adze. 10-11: Two narrow blades used as knives. 12: Fabricator with well-used gouge-type edge on its lateral margin. 13: Semi-discoid scraper. 14: *Tula* adze slug; 15: End scraper. 16: Side and end scraper, with convex ends. 17: End scraper. 18: Side and end scraper. 19: Notched scraper. 20: End scraper with narrow trimmed convex end. 21: Side and end scraper, with rounded nose between concaves. 22: Side and end scraper, with narrow nose on distal end. 23: Prismatic core remnant used as a fabricator at one end. 24: Double side scraper tending to being a *Burren* adze slug. 25-6: Double side scrapers. 27: Heavily-used side scraper.

Plate 24, Bondaian, Site 3.—Fig. 1: Saw from various layers. 2: Quartz flake hafted in beeswax. 3: Two rows of *Bondi* points. 4: Two rows of geometric scrapers, including a quartz discoid (second from left) and a neatly trimmed oval geometric (second from right). 6: Thumbnail scrapers. 7: Broad oblique trimmed blade. 8: Double side scraper with concave working edges. 9: *Burren* adze slug. 10: Microlithic scrapers. 11: Bone awl. 12: Pointed bone, probably part of a nose bone. 13: Small rounded portion of a mussel shell, carefully shaped, perforated at one end, probably part of a necklace or forehead band.

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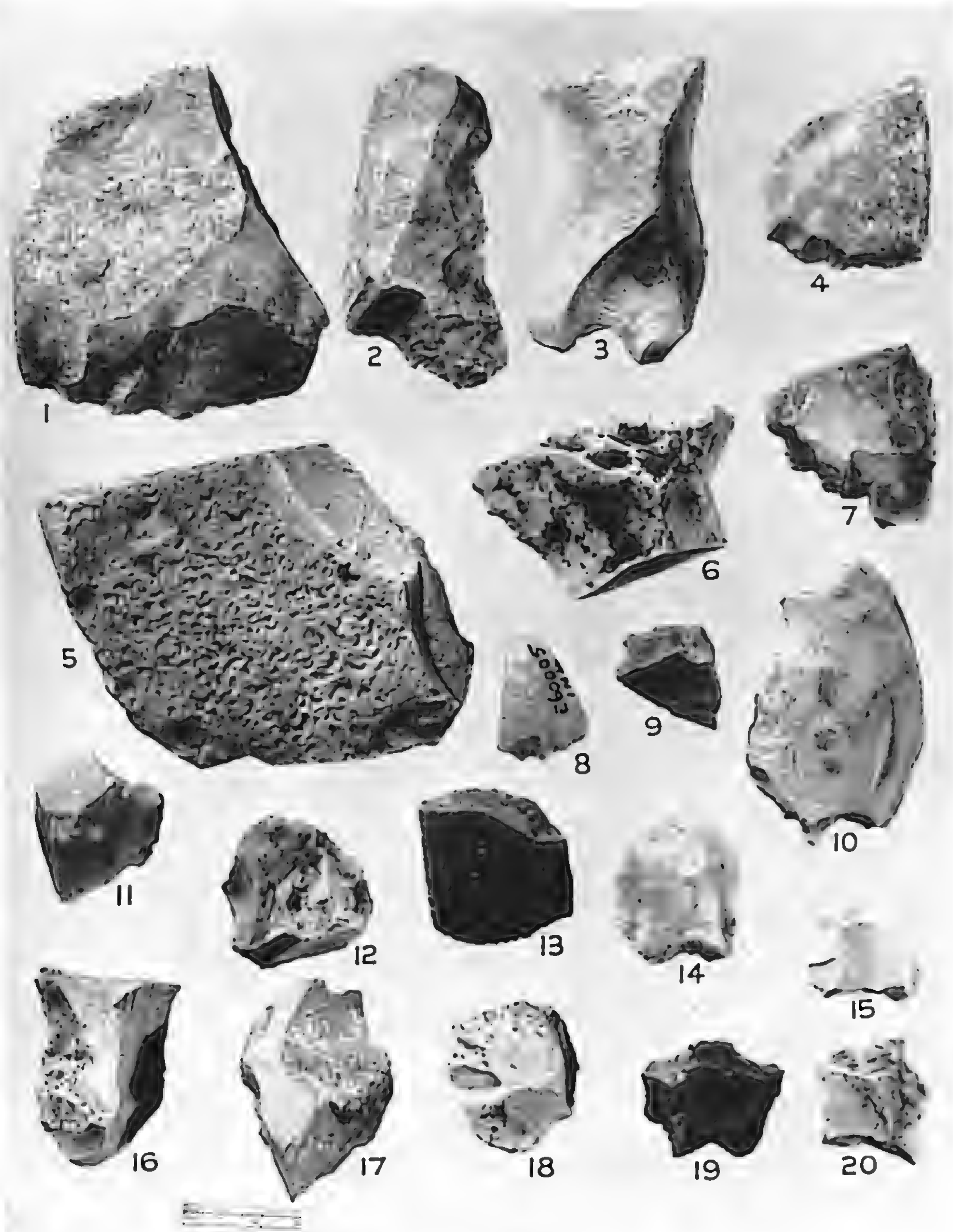
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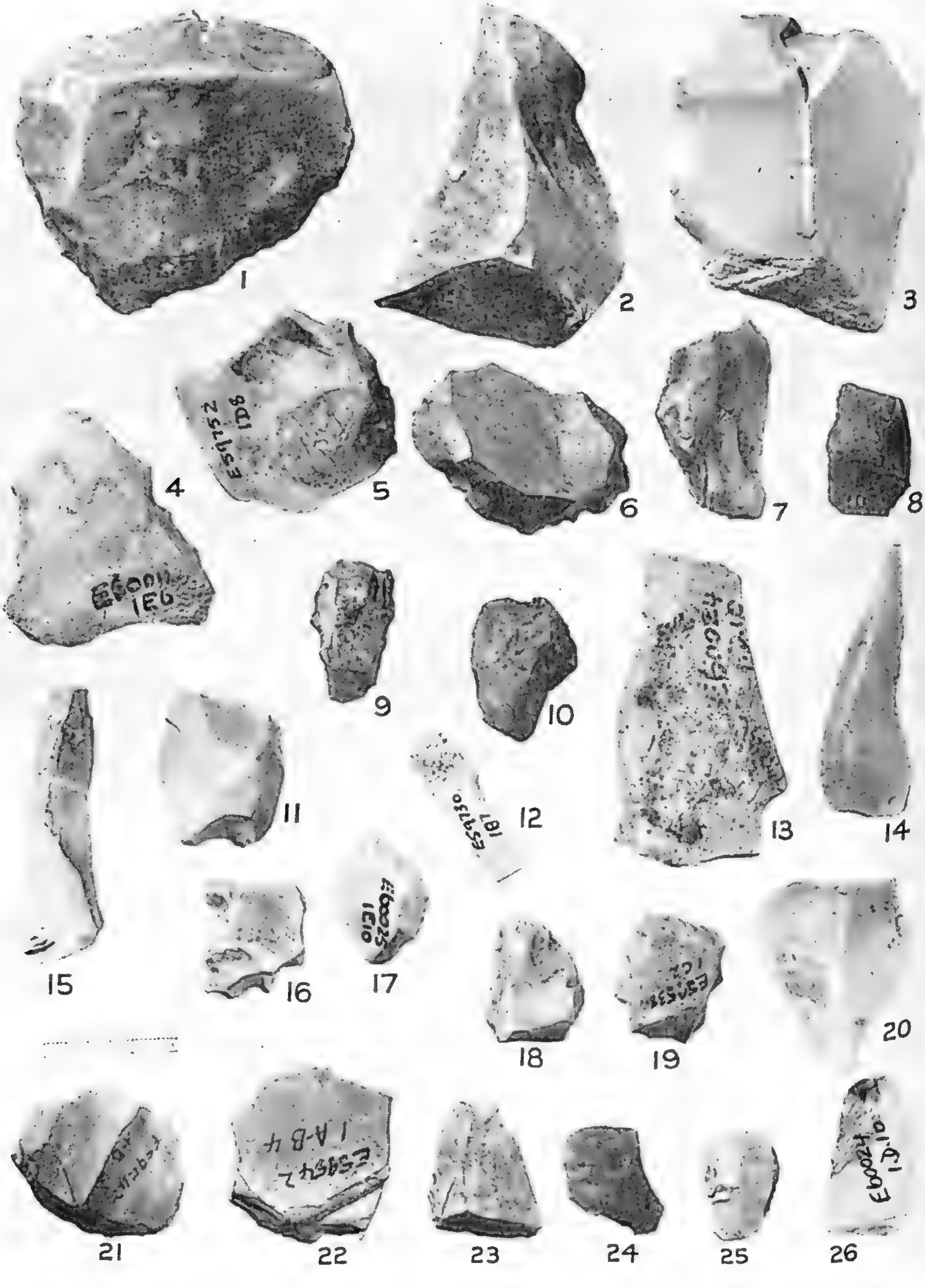
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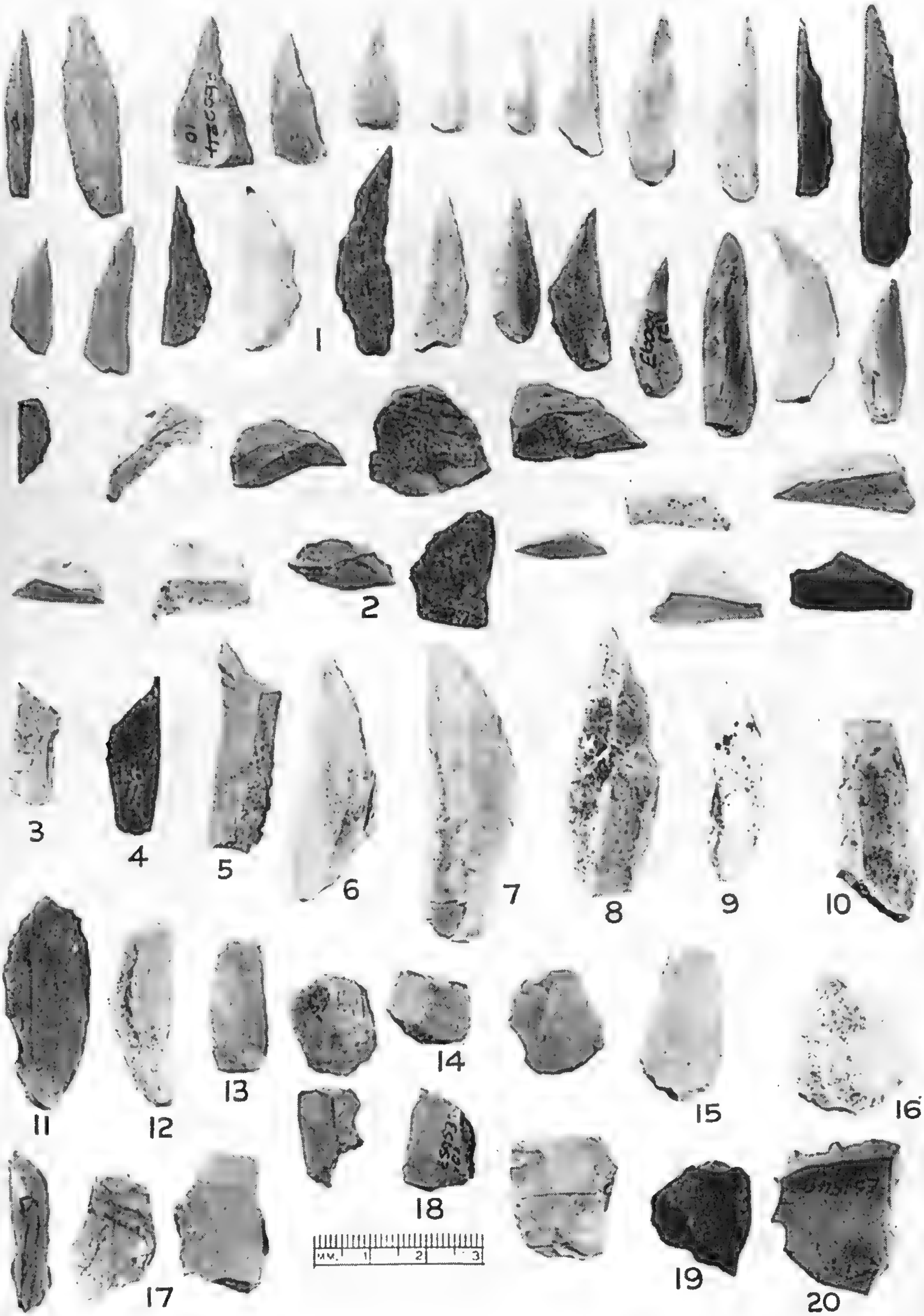
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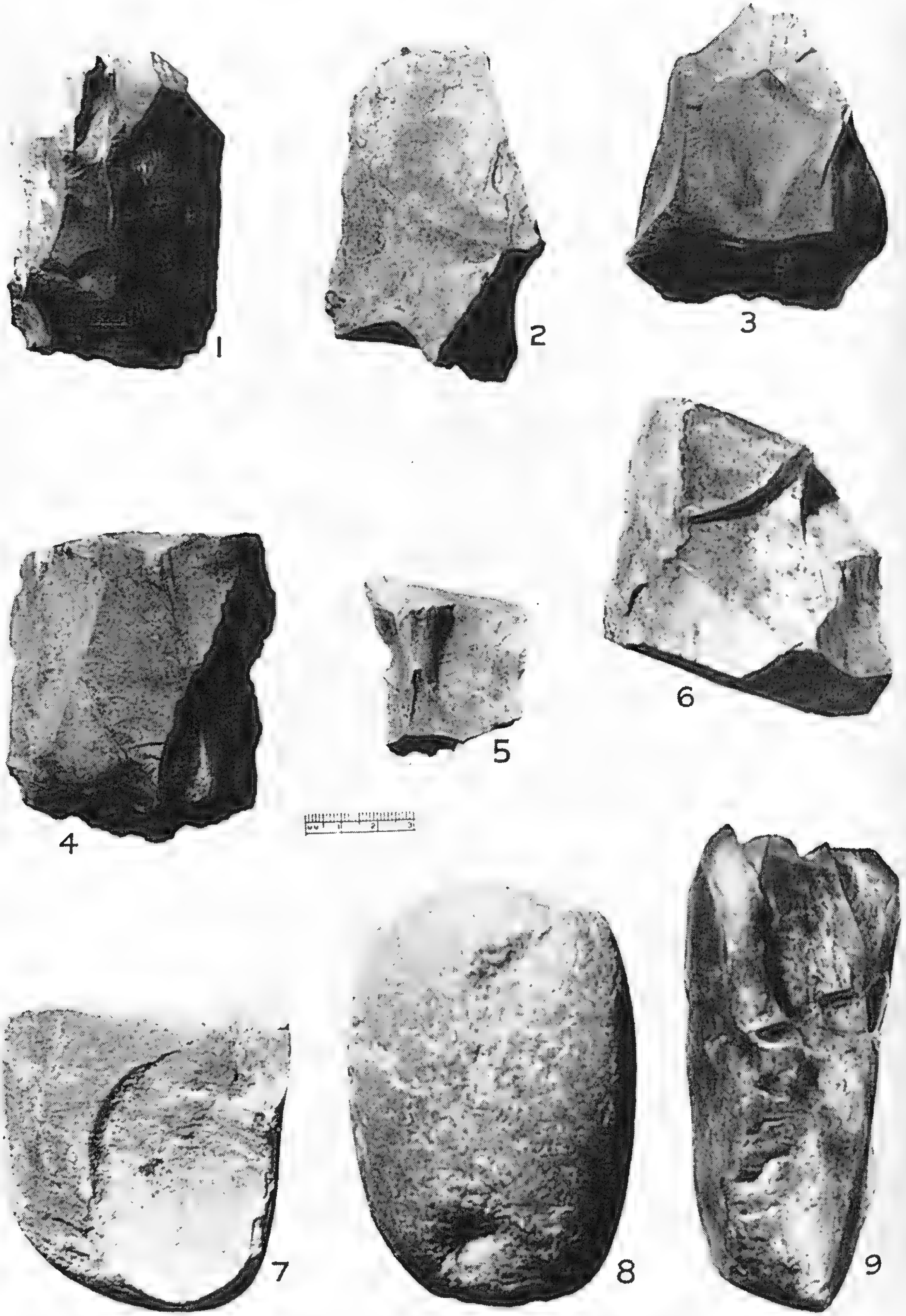
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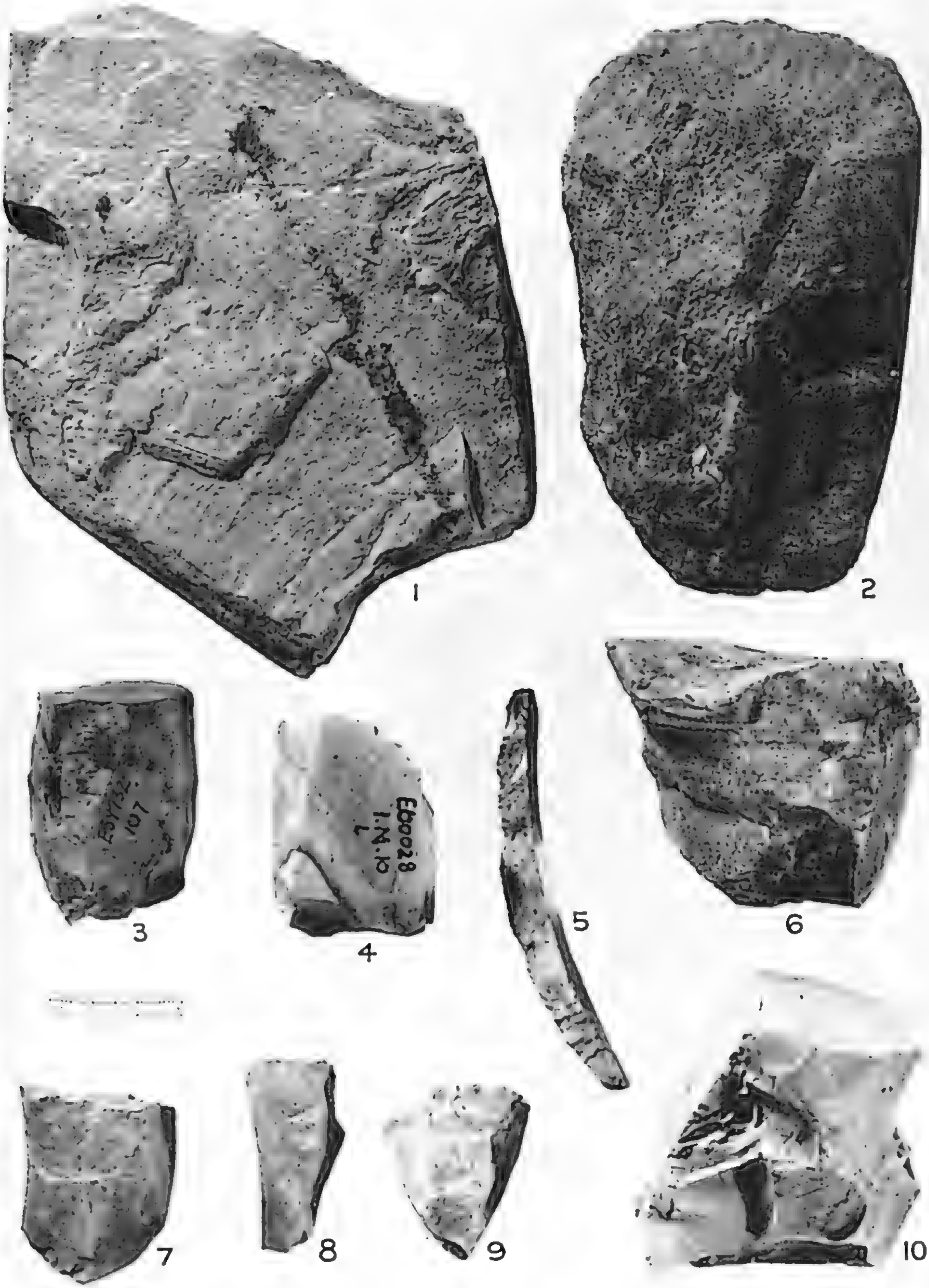
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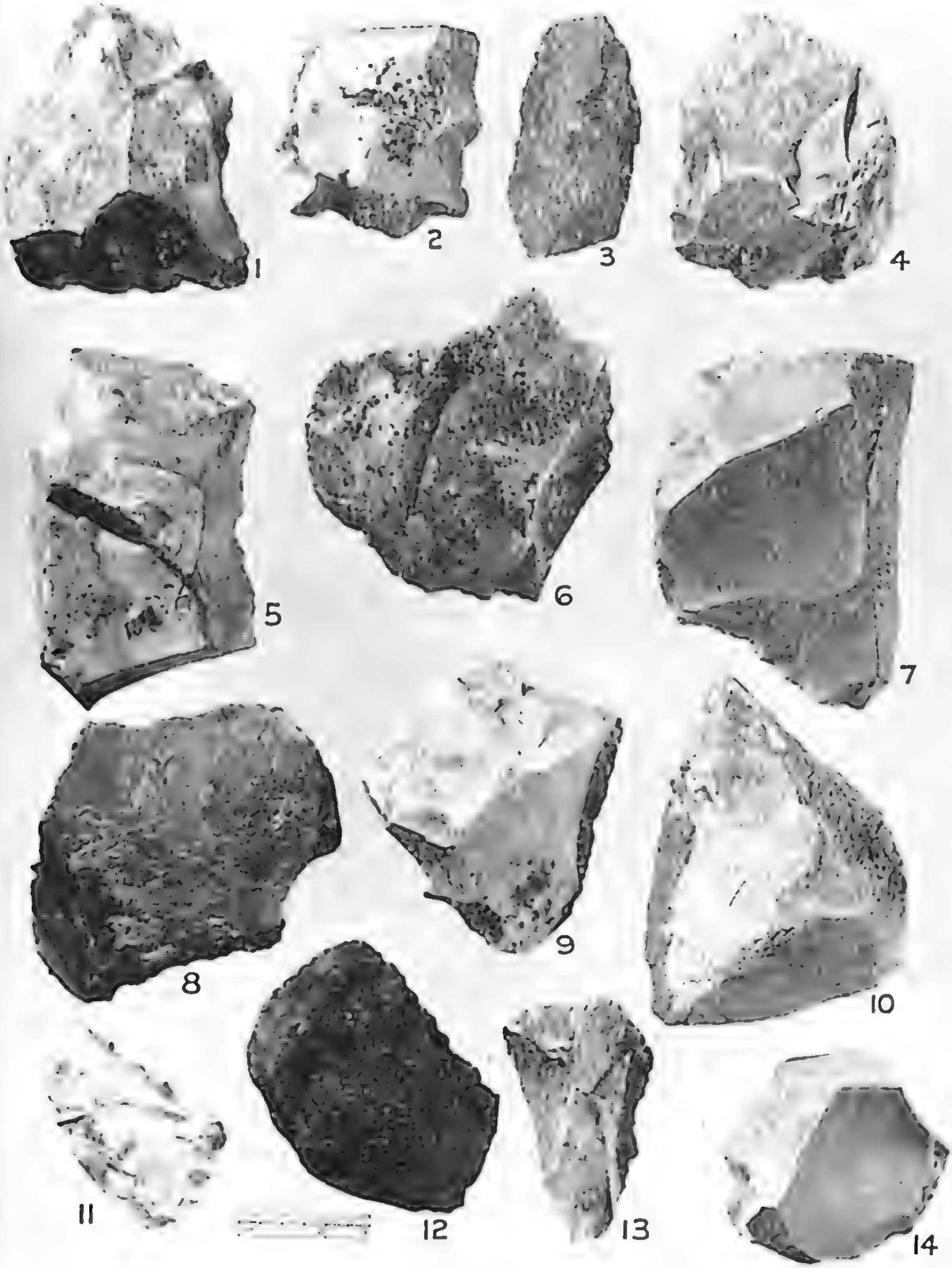
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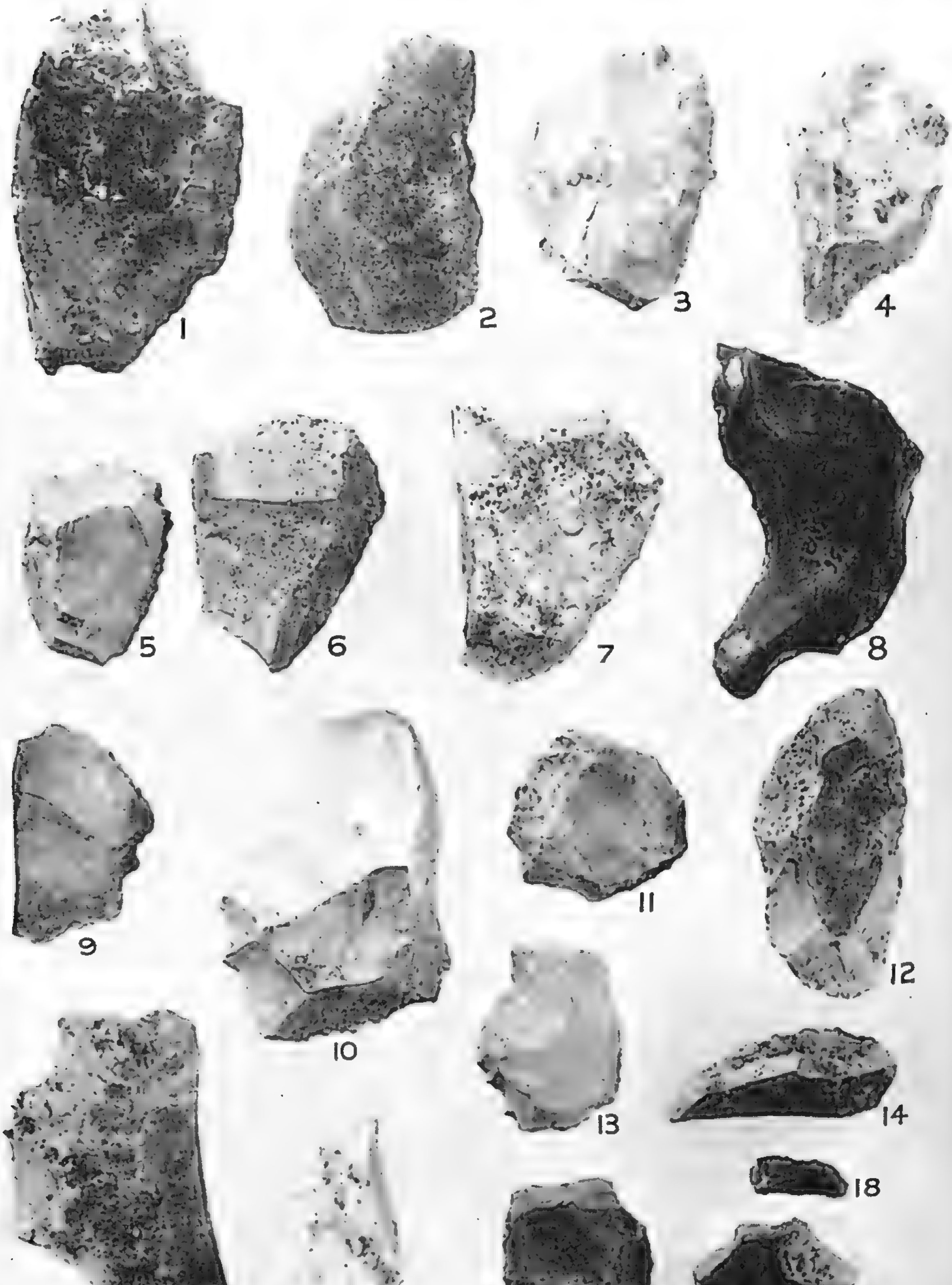
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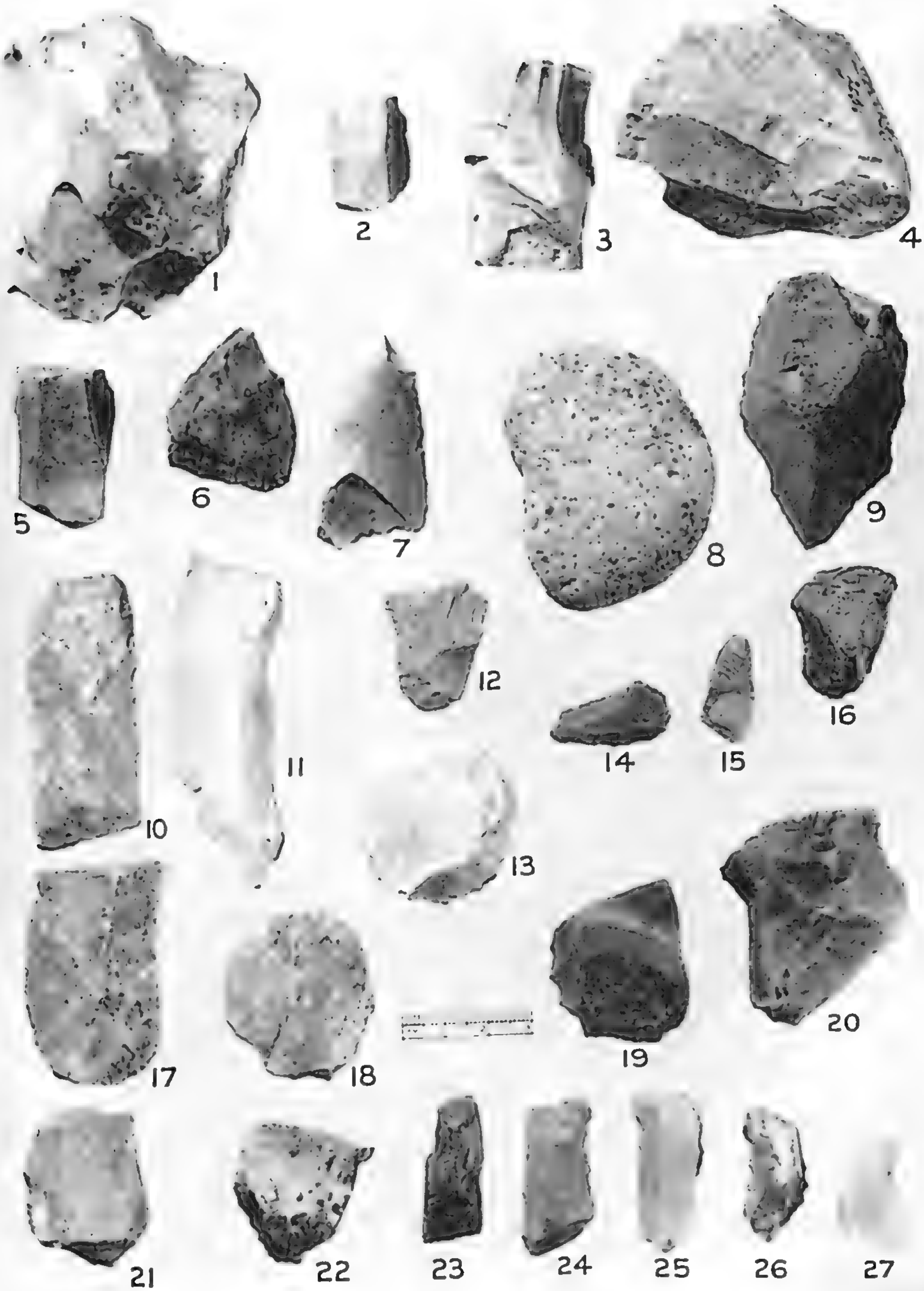
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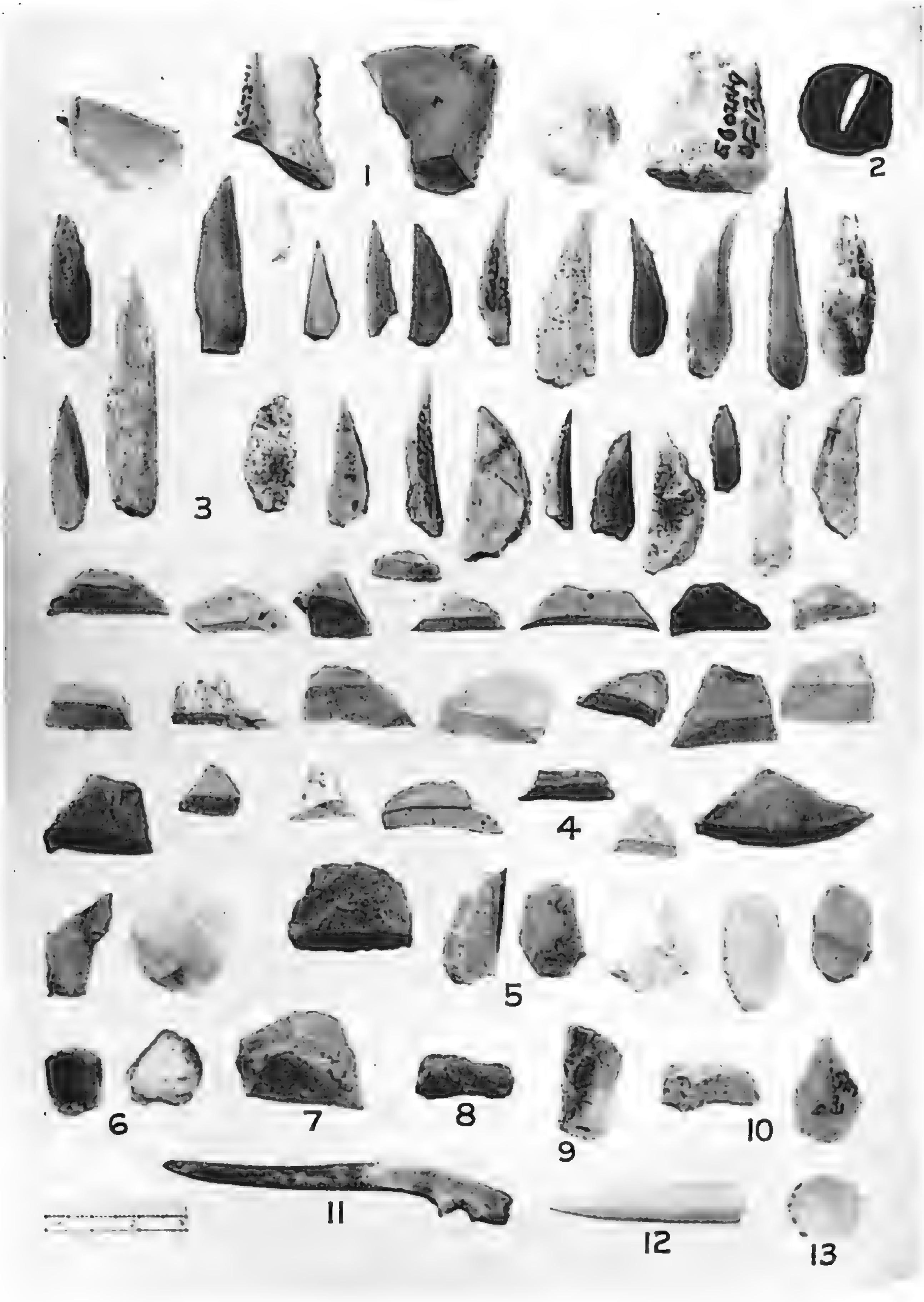
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Soil and Landscape History in the Vicinity of Archaeological Sites at Glen Davis, New South Wales

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Plates 25-27 Figs. 1-10 Manuscript received 22-1-63

I LOCATION

(i) Physiography

The archaeological sites are located on the lower slopes of the Capertee River Valley, approximately four miles downstream and to the east of the township of Glen Davis (see figure 1). The Capertee River flows east through a narrow gorge at Glen Davis which is bounded by precipitous scarps of Triassic, Hawkesbury and Narrabeen sandstones over 1,000 feet high (see Plate 25), while at the base the Lithgow coal measures of Permian age are occasionally exposed (see Dept. Nat. Devel. 1957).

The location in which the archaeological sites occur is separated from the main scarp by a minor scarp below which a talus slope, pediment, steep slope and lower slope occur (figure 2). The sites are in rock shelters on the lower slopes and are formed from erratic sandstone boulders which vary from 40 to 150 feet in diameter. The shelters, which are shown in relation to the river in figure 3, are shallow caverns near ground level and the richest finds of implements and other occupational materials are within the cavern or directly at the mouth.

Of the three cave sites which were excavated, only caves 1 and 3 contained deep cave floor deposits; site 2 was very shallow and is not considered in this discussion.

(ii) Unconsolidated deposits and country rock

The Capertee valley is characterized by several hundred feet of very coarse, bouldery sandstone talus which occurs at the base of the main scarp. It is very intensively weathered, as evidenced by its clayiness and deep, reticulate white and red mottles. The present course of the river is incised into the talus deposits with narrow river terraces above the river bed. The remaining talus deposits above the present level of influence of the main river have been modified by superficial mantle movement and by slight incision of ephemeral streams.

The superficial hillside deposits which cover most of the thick talus vary from shallow sandy sediments with abundant rock fragments randomly scattered through the deposit to sandy, less stony sediments 6 to 8 feet deep on milder slopes about the cave sites. Evidence of past movement of these materials can be seen in the superficial debris piled on the upslope side of sandstone boulders (see figure 4). Under the present environment, however, these deposits are stable and there is little evidence of present day erosion and deposition on hillsides.

The river deposits occur as terraces up to 30 feet above the river bed (figure 3) and are typically of stratified sands with thin bands of interbedded organic debris. The terraces are confined within the river channel so that a steep embankment of talus occurs 6 to 10 feet above the level of the river deposits. The deposits of the ephemeral stream shown adjacent to the caves in figure 3, are thin, stratified and sporadic and entirely confined within the stream channel.

The country rock is a massive Triassic sandstone of highly quartzose mineral composition, and coarse sandy and gravelly mechanical properties (see Dept. Mat. Devel. 1957). It is characterized by strong current bedding such as can be seen in Plate 26.

(iii) Cave floor deposits

The cave floor deposits are loose, unstratified, sandy materials containing fewer rock fragments than surrounding hillside deposits. The nature of deposits in caves 1 and 3 is shown diagrammatically in figures 5 and 6.

The section across cave 1 reveals a loose, sandy deposit which is almost entirely free of rock fragments within the shelter of the cave. The face of the pit was lightly trowelled to expose rock fragments and these are plotted in figure 5. Where the rock fragments made up a large proportion of the deposit the diagram is not a plot of the actual position and amount of fragments. The boundary between the sheltered sediments and the stony deposits outside the cave is abrupt and vertical and coincides with the outer edge of the overhanging cave roof. The rock floor of the cave is very irregular and consists of large angular boulders. There seems little doubt that the body of sandy sediments which is virtually free of rock fragments represents the " cave deposit " as distinct from the general stony hillside deposits and bouldery talus. The occasional sandstone fragments, 4 to 12 inches in diameter, which occur randomly in the cave deposits, are most likely the result of flaking of the cave wall, a current process of weathering of the sandstone.

The sections in cave 3 show a similar arrangement of fragment-free sediment, i.e., cave deposit, within the shelter of the cave (see figure 6) and in each case the rocky cave floor rises towards the ground surface at the front of the cave. The stony deposit, similar to that in cave 1, is evident in the mid- and west-sections but its position in relation to the overhanging rock features of cave 3 is not clear.

(iv) Particle size properties of the sediments

Samples of the deposits were taken from sites shown in figure 3. The sedimentary properties within the particle size range of 0.002-50 mm. are shown in figure 7 as cumulative or summation graphs. These are representative data taken from a greater number of samples, the results of which are discussed in a separate paper.

It is evident from the summation curves that the modal particle size of the Triassic sandstone rock is comparable with the modes of the local unconsolidated sediments in the range 250-800 microns, so that there is no reason to suggest a source of sediment in this locality other than the sandstone rock itself. The modal particle size of the unconsolidated sediments is of a range which is readily transported by wash or wind saltation (Bagnold, 1941) and not of the modal particle size of loess (Zeuner,

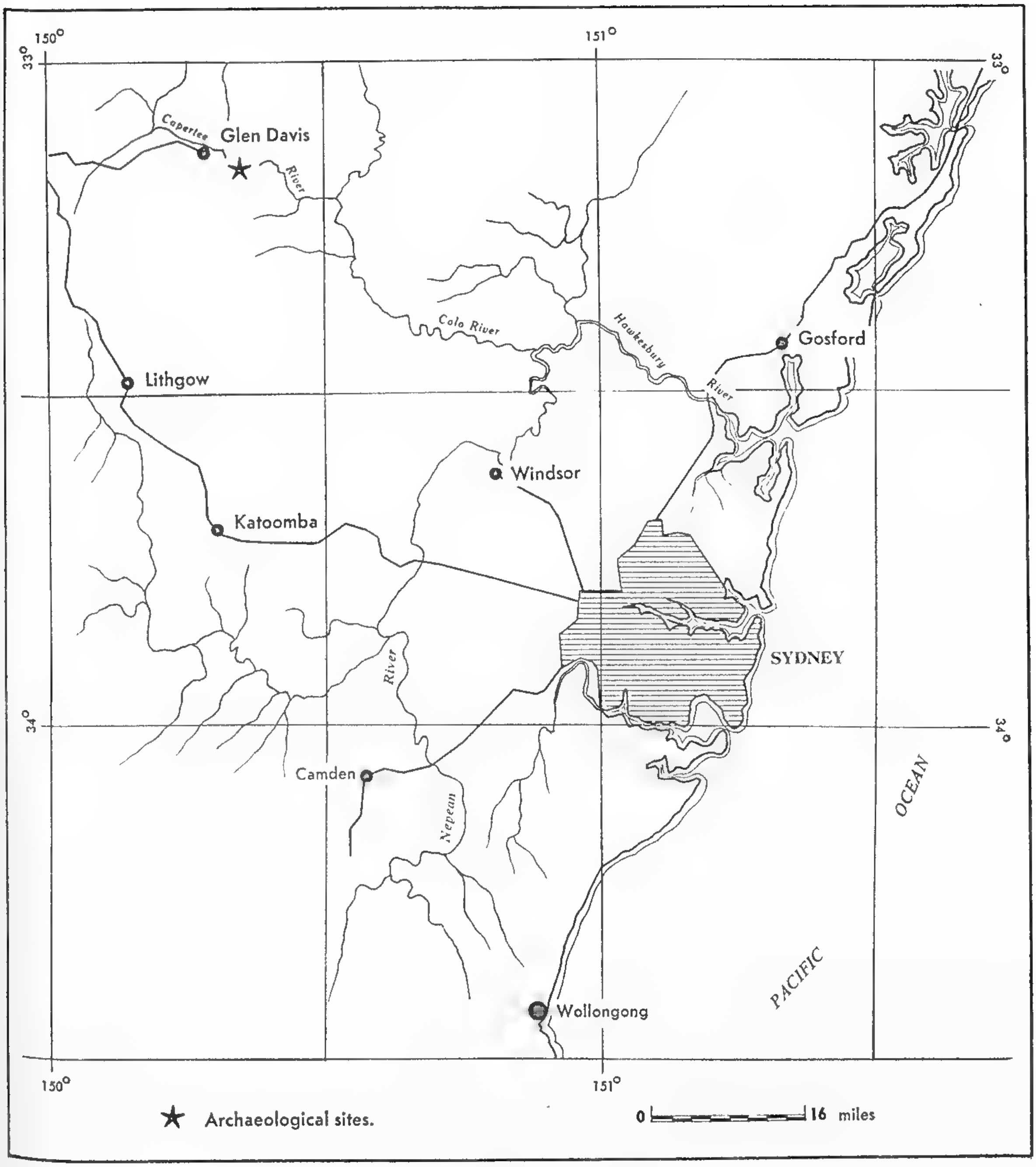


Fig. 1

1945) or parna (Butler and Hutton, 1956). The central slopes of the summation curves show that river and stream deposits are more strongly sorted than other unconsolidated sediments and that cave and hillside deposits have similar, less strongly sorted sediments. It is probable that the cave deposits are derived from adjacent hillside sediment by localized wash and/or wind action.

Both from the analyses and the more general properties observed in the excavations, the cave deposits appear to be unique deposits in this locality; they are the results of deposition of coarse sandy material in a sheltered environment. The cave sediments occur as islands of relatively stone-free material which have neither the stoniness of surrounding hillside deposits nor the sedimentary stratification and strong particle sorting of river sediments.

II THE SOILS*

*Soil descriptions follow the system of Butler (1955) and the colours are expressed in the Munsell notation, using moist soil.

The soils throughout this locality are very weakly differentiated into surface (A) and subsoil (B) horizons; textures are seldom outside the sand range throughout the profile, and the presence of a pale A_2 horizon and thin bands of clay at depth suggests weak leaching. Field pH determinations ranged from 5.5 to 7.0 with profiles having fairly uniform pH values throughout.

The soil descriptions below are generalized from numerous profile observations, almost all of which are located within the area shown in figure 3. In a later section, a discussion of the soil stratigraphy on hillside and talus slopes is based on the soil layers which are described in this section. Each layer is assigned a letter P, Q, R, S or T and these are shown against the appropriate descriptions below.

(i) Soil of weathered talus

The surface is a dark (10YR211), stony, loose and powdery loamy sand which passes gradually to a reddish (5YR414 to 516) brittle and powdery sandy loam by 12 inches with frequent sandstone boulders (soil layer T); by 36 inches the profile is bouldery with a more or less continuous matrix of pale (2.5Y7/4) coloured sand which is partially cemented to red (10R3/6) and yellow (10YR6/6) mottled nodules 4 inches in diameter; this zone continues to at least 5 feet. In deep river cuttings, a red (2.5YR4/8) and white (10YR8/1) reticulately mottled, bouldery, plastic clay forms a thick basal weathered zone within the talus deposit, well below the red soil described above.

(ii) Soils of hillside deposits

These are sandy soils with sandstone rock fragments more or less scattered throughout, but increasing with depth. The surface is 1 to 2 inches of black (10YR2/1) loose and powdery loamy sand, seldom with sandstone fragments (soil layer P); it passes through 12 inches of brown (10YR4/3) loose sand with a few sandstone fragments (soil layer Q) to a pale brown (10YR7/4) subsoil of very weakly cemented sand with increasing sandstone fragments (soil layer Q). Frequently large sandstone boulders up to 2 feet in diameter are encountered within 2 feet of the surface, but where the superficial hillside mantle is deeper, thin bands of red (2.5YR4/6) clay appear in the deep subsoil (soil layer R) and become half an inch thick at 60 inches depth (soil layer S).

(iii) Soils of river and ephemeral stream deposits

These are sandy materials showing distinctive depositional bedding or stratification which has not been modified by soil forming processes. The profile consists of alternating bands of dark brown (10YR4/2) and pale brown (10YR6/3) loose sand and black (10YR2/1) plant debris.

(iv) Soils in the floor of cave 1

These soils are shown diagrammatically in figure 8 without reference to the rock fragments which were discussed earlier. The surface is a dark grey (10YR3/1) loose sand, enriched with charcoal fragments both inside and outside the cave (soil layer P). Outside the shelter of the cave, i.e., on the left side of figure 8, the surface

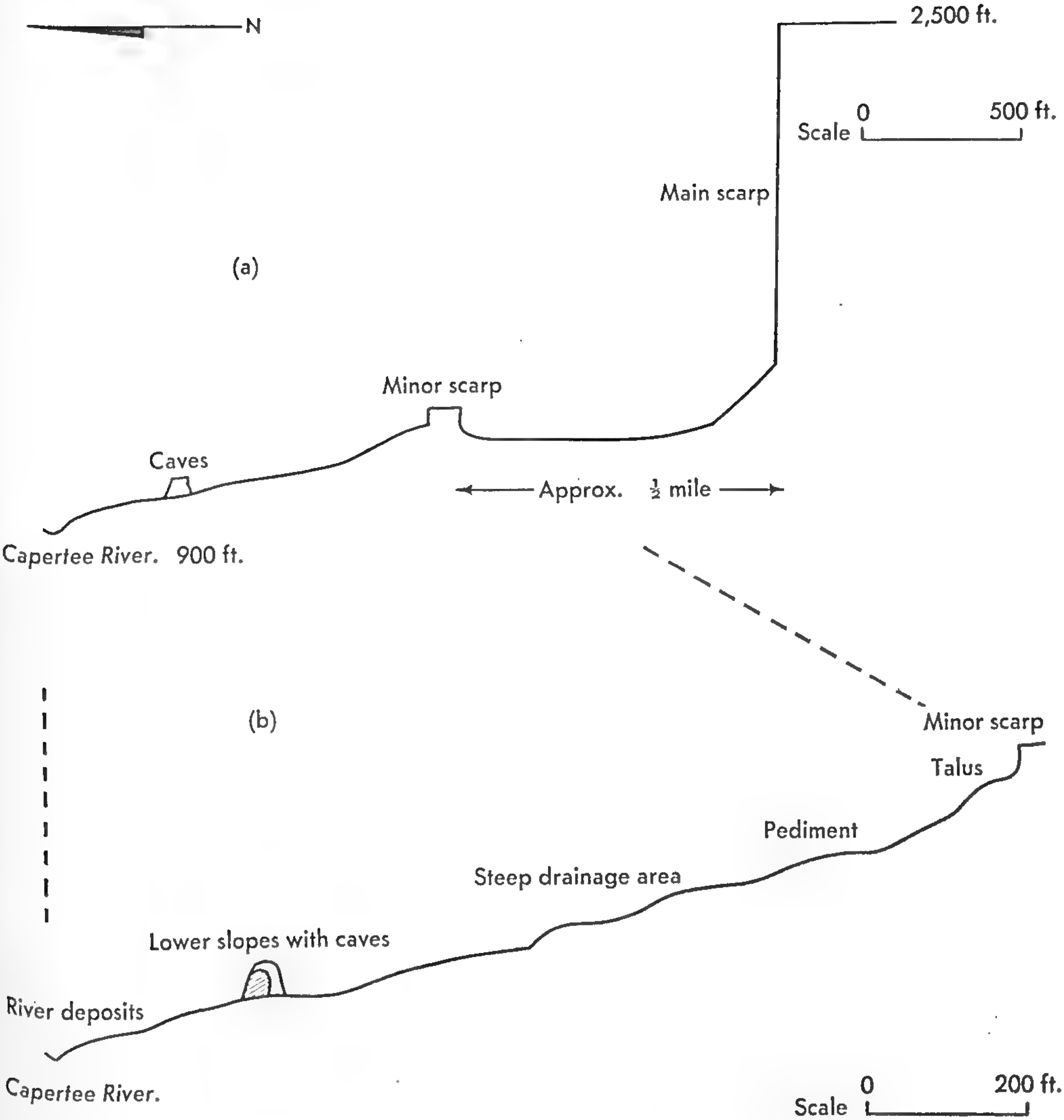


Fig. 2

passes into a pale brown (10YR6/4), loose sand (soil layer Q). These layers of the profile overlie a darkened (7.5YR3/2), charcoal-enriched zone which is partially enclosed by a hardened red (2.5YR4/6) sandy soil; this was considered to be a buried Aboriginal fireplace with an adjacent "burnt" soil zone. To the left of the buried fireplace, the pale brown sandy soil passes at 18 inches into a pale reddish brown (7.5YR6/3) weakly-cemented sand which contains thin (1/16 inch) red (5YR5/6) wavy bands of clay 3-6 inches apart (soil layer R) dipping at a steep angle to the present ground surface and continuous across the face of the excavation. At 40 inches this soil layer passes abruptly into a white (7.5YR8/4) loose sand which contains red (2.5YR4/6) wavy bands of clay, up to 1 inch thick which run horizontally through the soil (soil layer S). Rock fragments in this soil layer are also coated with the red clay which forms a thicker deposit on the upper surface of the fragment than on its lower surface. At 60 inches there is an abrupt change to a zone predominantly

of sandstone boulders; the soil is a brightly mottled red (2.5YR4/6) and yellow (7.5YR6/8) moderately-cemented sandy loam without clay bands, which continues to the bottom of the excavation (soil layer T). Similar soil material was obtained to a depth of 9 feet, where boring ceased due to impenetrable rock.

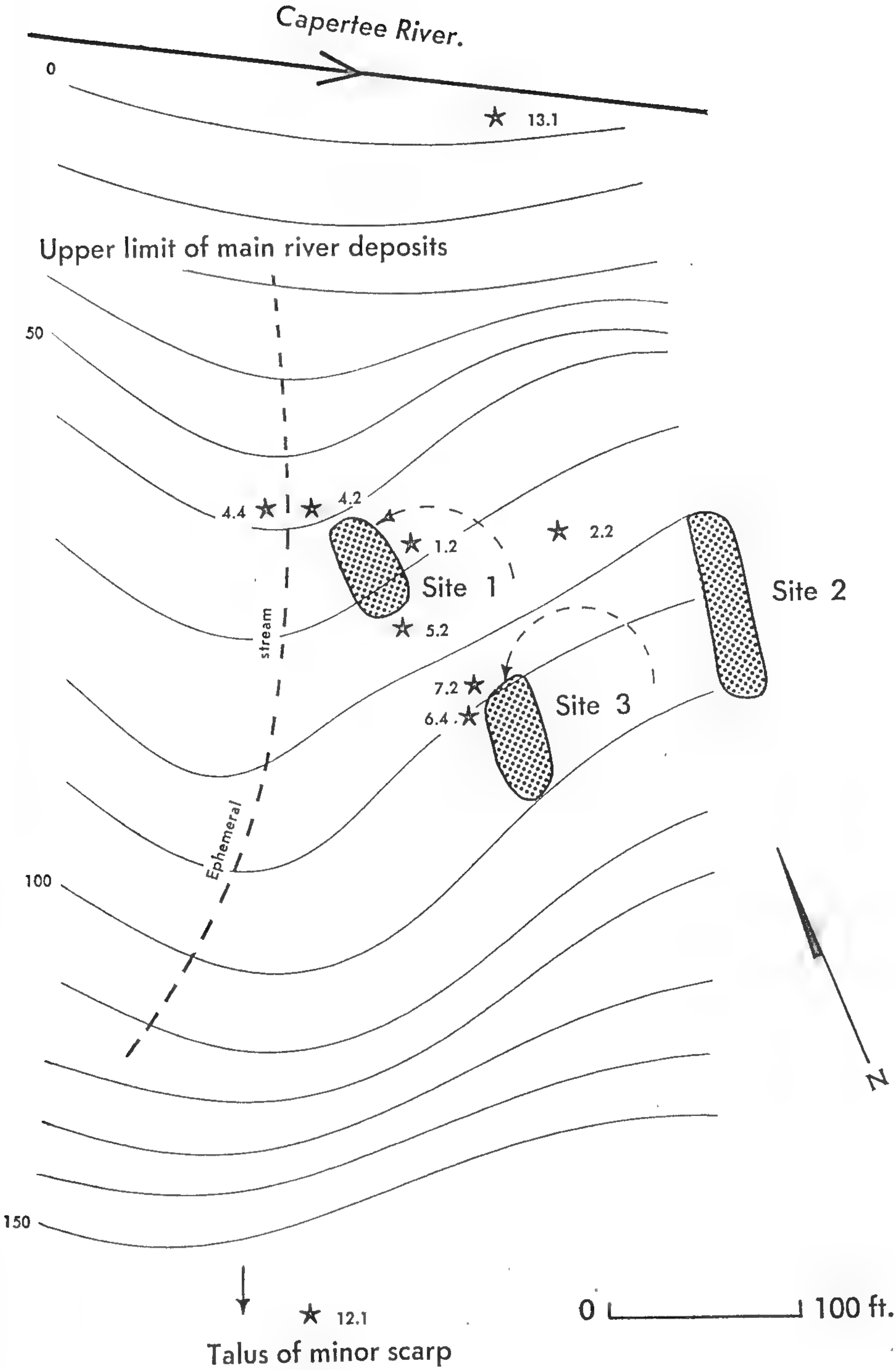
The soil within the shelter of the cave, i.e., on the right-hand side of figure 8, is very clearly separated from the soil outside it which has just been described. An abrupt vertical boundary separates the two bodies of soil and coincides with the boundary between stone-rich and relatively stone-free sediments. Apart from the buried fire-place, most of the soil within the cave is a very fragile sand and powders more readily than other soil material in the locality. The dark grey (10YR3/1) loose, sandy surface is of variable thickness and is rich in charcoal fragments (soil layer P); it passes into a pale brown (7.5YT6/4) sand which is very loose, powdery and contains numerous faunal channels a quarter of an inch in diameter. Between 36 and 48 inches the soil becomes a reddish-coloured (5YR5/8) loose sand with slight white (10YR8/2) mottling and there is evidence of thin (1/16 inch) clay banding toward the back of the cave. At 76 inches there is an abrupt change to a red (2.5YR4/6) and yellowish (5YR5/8) mottled, cemented sandy loam, relatively stone-free and containing a profuse network of branching channels three-quarters of an inch in diameter (soil layer T); this zone of soil is continuous across the base of the excavation and is connected to the material below 60 inches on the left-hand side of figure 8, which has a comparable morphology. By 84 inches the whole section becomes very bouldery and is considered to be the talus zone.

The occurrence within cave 1 of a unique soil developed within a unique deposit indicates that the cave environment is unique in this locality. It will be noticed, however, that while the upper 5 or 6 feet of the excavation provides a contrast in adjacent soils inside and outside the cave, the basal soil material, except for stoniness, is similar across the excavation. Since artifacts are virtually absent from this basal soil and occur thickly through the loose sandy layers above it, it is probable that the differences between soils inside and outside the cave are largely the result of human occupation of the sheltered environment.

(v) Soils in the floor of cave 3

The soil properties of the east and west sections of cave 3 (figures 9a and 9b) differ considerably. The east section is similar to soils outside the cave and has a dark grey (10YR3/1), loose, sandy surface (soil layer P), which passes to a loose pale brown (10YR7/4) sand (soil layer Q); at 24 inches, thin (1/16 inch) horizontal bands of red (5YR4/6) clay appear and these become progressively thicker with depth down the profile to 66 inches where they are half an inch wide and still horizontal. This soil passes abruptly into a red (5YR5/6), weakly-cemented sandy loam which forms the matrix of the basal, bouldery talus zone (soil layer T).

Adjacent to the cave wall in the west section, the soil has a thick, darkened (10YR3/1) (soil layer P), very loose and sandy surface which is rich in charcoal fragments; at 15 inches the surface soil passes into a light brown (10YR6/3-10YR7/4) very fragile sand with frequent faunal cavities (½-inch diameter). At 36 inches most of the profile in the west section changes abruptly to a stony layer, characterized by densely-packed, subrounded sandstone fragments up to 10 inches in diameter; in the upper part of this stony layer and immediately at its junction with the overlying soil, localized darkening (10YR5/2) occurs together with another concentration of charcoal fragments, indicating the occurrence of a buried fire-place. Through the layer of stones, reddish (5YR6/6) clayey bands occur (soil layer S) and at 6 feet the



Capertee River.
0
13.1
Upper limit of main river deposits
50
4.4
4.2
1.2
2.2
Site 1
Site 2
stream
5.2
7.2
6.4
Site 3
Ephemeral
100
N
150
12.1
Talus of minor scarp
0
100 ft.

Fig. 3

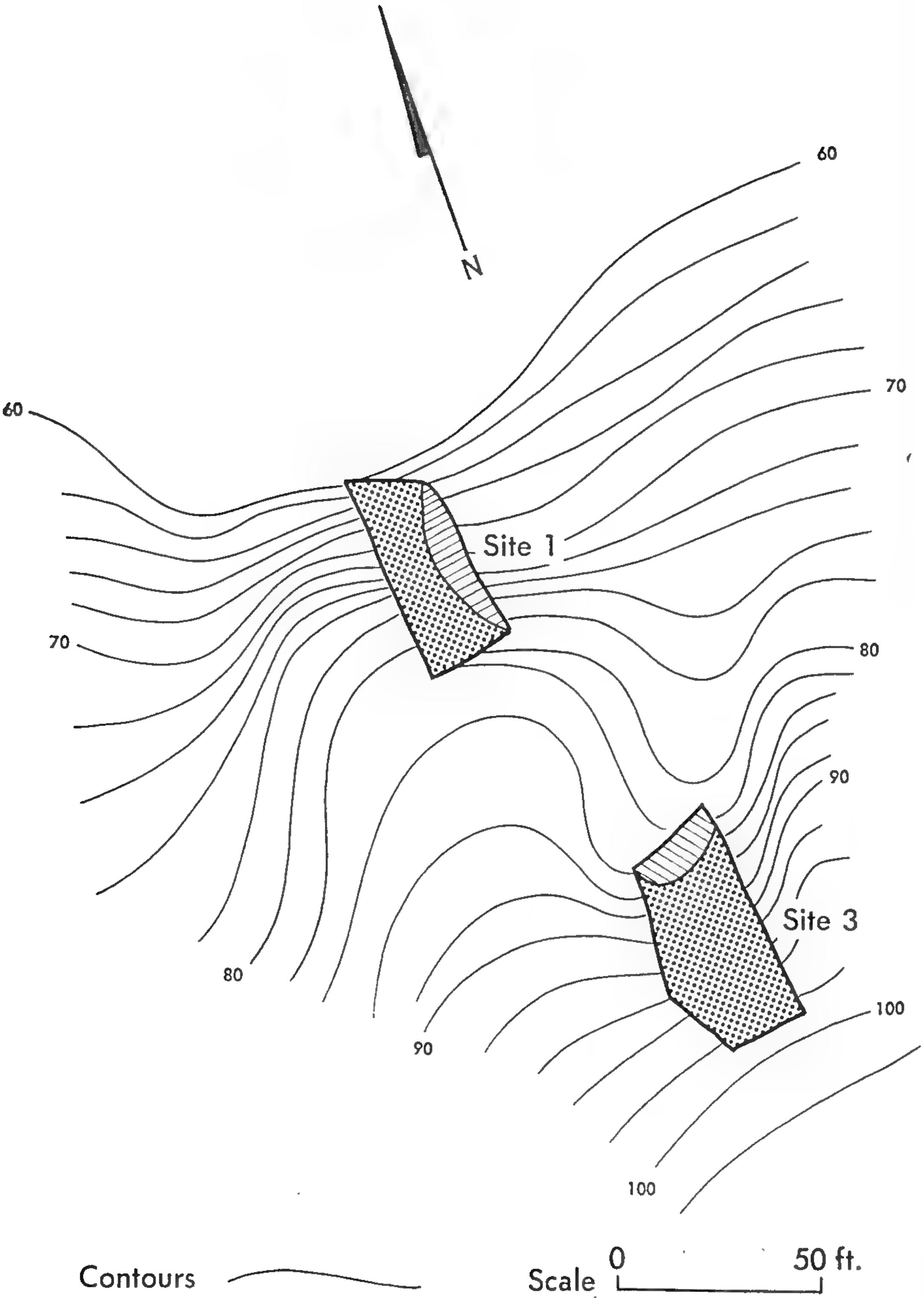

N
60
60
70
70
Site 1
80
80
90
90
Site 3
100
100
Contours
Scale 0 50 ft.

Fig. 4

soil passes abruptly into the basal bouldery zone which has a matrix of red (5YR5/6) weakly-cemented clayey sand (soil layer T). At the back of the cave in the west section, sandy material continues to depth uninterrupted by the stony layer; this material contains similar clay bands to the adjacent stony soil. Towards the mouth of the cave the upper profile is similar to that of the east section but the bouldery zone occurs closer to the surface so that the soil material with clayey bands is not evident in the accessible part of the profile. Some of the soils of cave 3, particularly those in the west section, show similar features of occupation to cave 1 and the contrast between sheltered cave soil and sediment and more exposed situations is equally as great. It is also significant that, as in cave 1, virtually no implements were found in the basal red soil of cave 3 among the talus boulders.

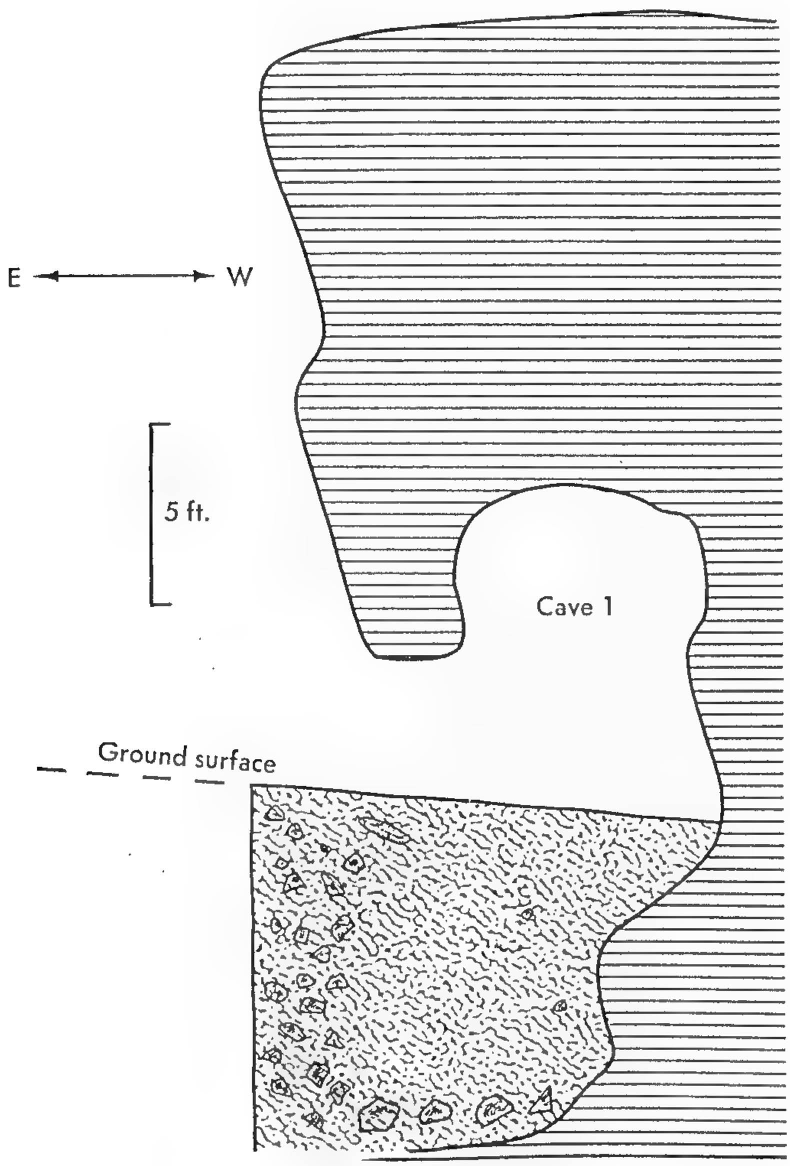


Fig. 5

III SOIL HISTORY

(i) Soil layering

Evidence of uncomfortable contacts between some of the soil layers is seen in the deposits just outside the shelter of cave 1. Layer P, the slightly organic sandy surface layer, is continuous with the thicker organic zone within the cave. A greater part of the dark coloration and depth of layer P within the cave is due to copious amounts of charcoal from Aboriginal fire-places. Layer Q is generally conformable with layer P and there is usually a diffuse boundary between them. The soil material in layer Q is sandy, loose, and single-grained, and together with the surface layer P, probably represents a single pedological system *PQ*.

The upper boundary of layer R is sharply separated from layer Q, but lies conformably in relation to P and Q. A clear break between layers Q and R also occurs where a patch of blackened earth and baked soil separates them, indicating a phase of human occupation subsequent to the deposition of layer R and prior to Q. No indication is given of the length of human occupation insofar as it may indicate a period of general surface stability in the locality. Layer R contains long, thread-like bands of clay which dip at a steep angle to the present soil surface; they confirm

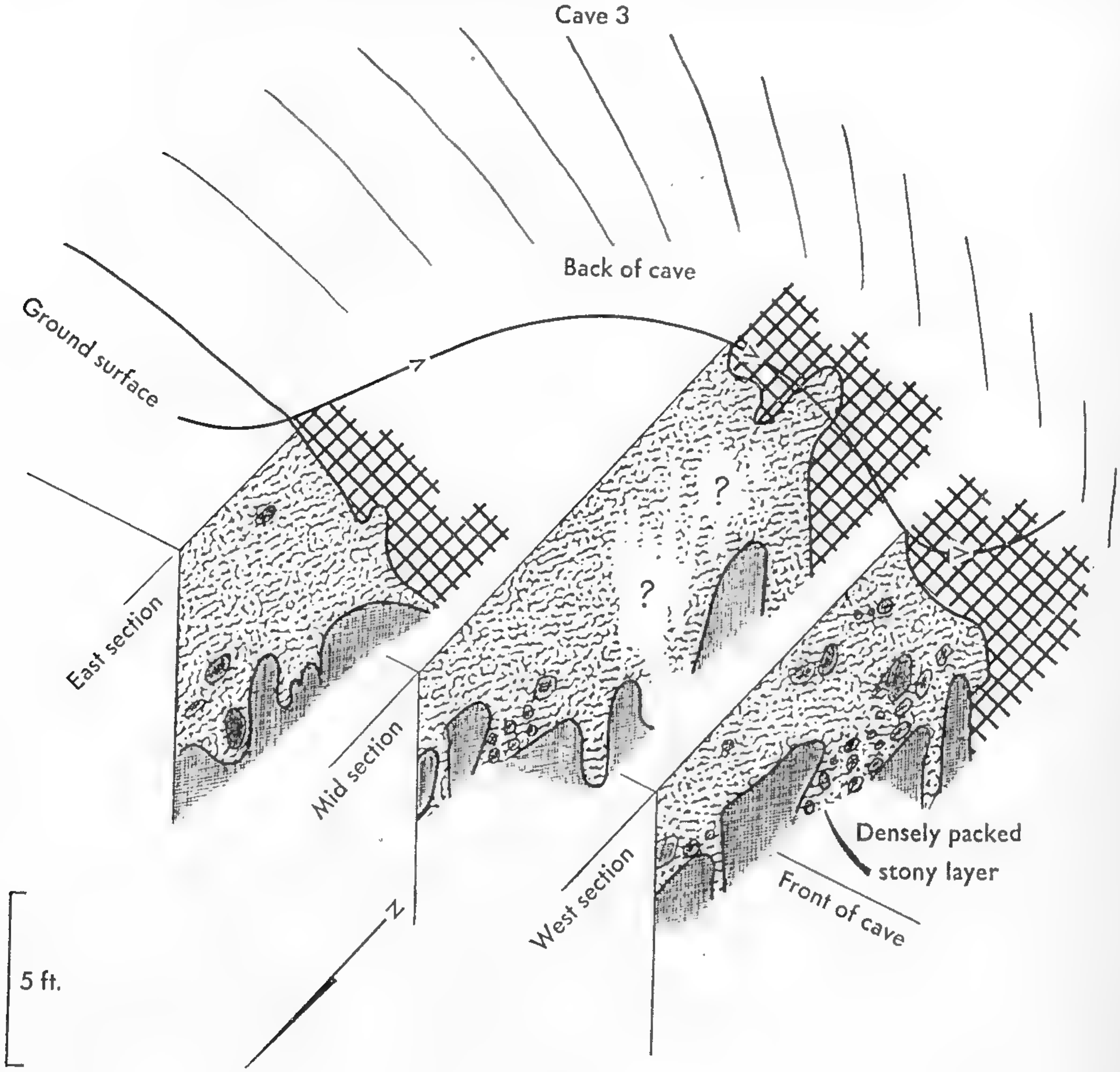


Fig. 6

the presence of an unconformity between layers Q and R and indicate deposition of materials to form layer R and segregation of clay prior to deposition of material in soil *PQ*. Layer S is also abruptly separated from layer R by an unconformable soil contact; the soil materials are much more strongly segregated in S, and the thick bands of clay have horizontal orientation in contrast with the thin, dipping clay bands within layer R. The evidence suggests that the sediments of layer S were deposited, stabilized and subsequently weathered prior to the deposition of the sediments of layer R. Soil layer T is not abruptly separated from S outside cave 1, but within the shelter of the cave there is a very sharp boundary between layer T and the cave soil above it. Soil T has attributes of the talus soil and is virtually free of artifacts (McCarthy, private communication).

Unconformable contacts between the younger soil layers is also evident in the cutting made by an ephemeral stream adjacent to the caves (figure 3). The uppermost materials are a slightly organic surface which grades into a single-grained sand; a thick gravel layer separates this zone from the layer beneath and the boundary between them is steeply dipping and iron-stained. Below this boundary the soil is a

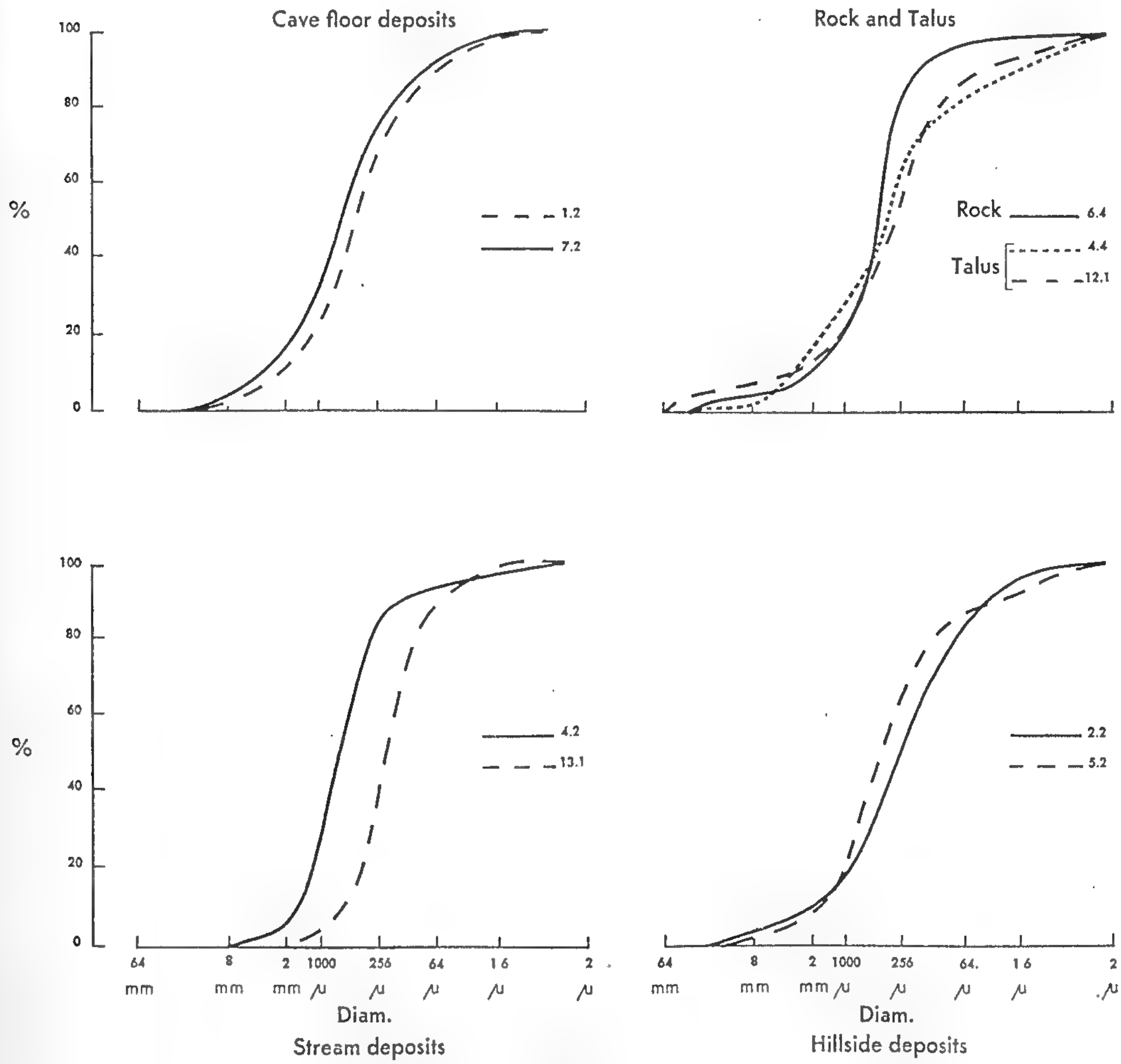


Fig. 7

slightly cemented sand with thin wavy, thread-like bands of clay oriented parallel to the general surface. In this case the gravelly layer marks the boundary between soils with the morphology of soil *PQ* and layer R adjacent to cave 1.

The soils adjacent to and within cave 3 do not show the unconformities so evident in cave 1. This may be explained in part by the oreintation of cave 3 in relation to the megalith; its position is more sheltered from hillside erosion than cave 1. The eastern section of cave 3 has the same soil materials as the section outside the shelter of cave 1. There is a slightly organic surface (layer P) passing into a sandy zone (layer Q) with thin bands in the soil below (layer R) which increase in thickness with depth (layer S); the basal layer is a red, more clayey, soil amongst very coarse talus boulders (layer T). In this case, however, there are no evident soil unconformities and, apart from the great sedimentary difference between the basal talus and overlying sandy materials, the complexities of erosion, deposition and soil formation that were evident in cave 1 cannot be interpreted here. The western section of cave 3 shows a similar occupational soil to cave 1; in this case however a very distinct stone line occurs at the base of the occupational soil and separates it abruptly from the soil below which contains thick bands of clay in a stony soil (layer S). Once again the red soil of layer T is encountered within the very coarse basal talus deposit.

(ii) Discussion of soil events

The soils above layer T at cave 1 provide a marked contrast between relatively uniform undifferentiated materials inside the cave and materials with distinct clay segregation outside. The shelter of the cave would be expected to afford considerable protection against the direct effects of leaching which are evident outside the cave; in addition, the more or less continuous disturbance of cave deposits by man, together with the accretion of charcoal and other organic material, would tend to mask the evidence of soil formation. The presence of clayey material and segregations within layer T inside the cave indicate, however, that soil development does take place in the sheltered environment when man is absent from the site. The high permeability of the sediments is no doubt sufficient to permit the movement of colloids with seepage water which would encroach on sheltered sites. It is likely, therefore, that disturbance and accretion due to human occupation have been major factors in minimizing soil differentiation of layers corresponding to *PQ*, R and S within the cave, while in exposed sites these layers were weathered and clay was translocated to form bands of accumulation.

The sequence of events was similar within cave 3 except that organic accretion due to human occupation only occurs in layers corresponding to *PQ* and R. Layers S and T within the shelter of the cave have comparable properties to soil layers S and T in exposed sites.

The sequence of events outside the caves has been represented by soil layers *PQ*, R, S and T. Only two of these, the surface soil *PQ*, which is the general surface profile over hillsides in this locality, and the widespread talus soil T, clearly relate to particular surfaces of stability. The latter is the basal soil layer in the archaeological sites while the former is the product of present stability of the superficial hillside mantle which overlies the talus. The soil material between *PQ* and T in the stratigraphic sequence is characterized by distinctive clay bands in a sandy matrix. Similar bands of clay have been described in some sandy soils of the United States (Wurman, Whiteside and Mortland 1959; Bartelli and Odell 1960; Robinson and Rich 1960). They are considered to bethe result of periodic precipitation of clay which is translocated from

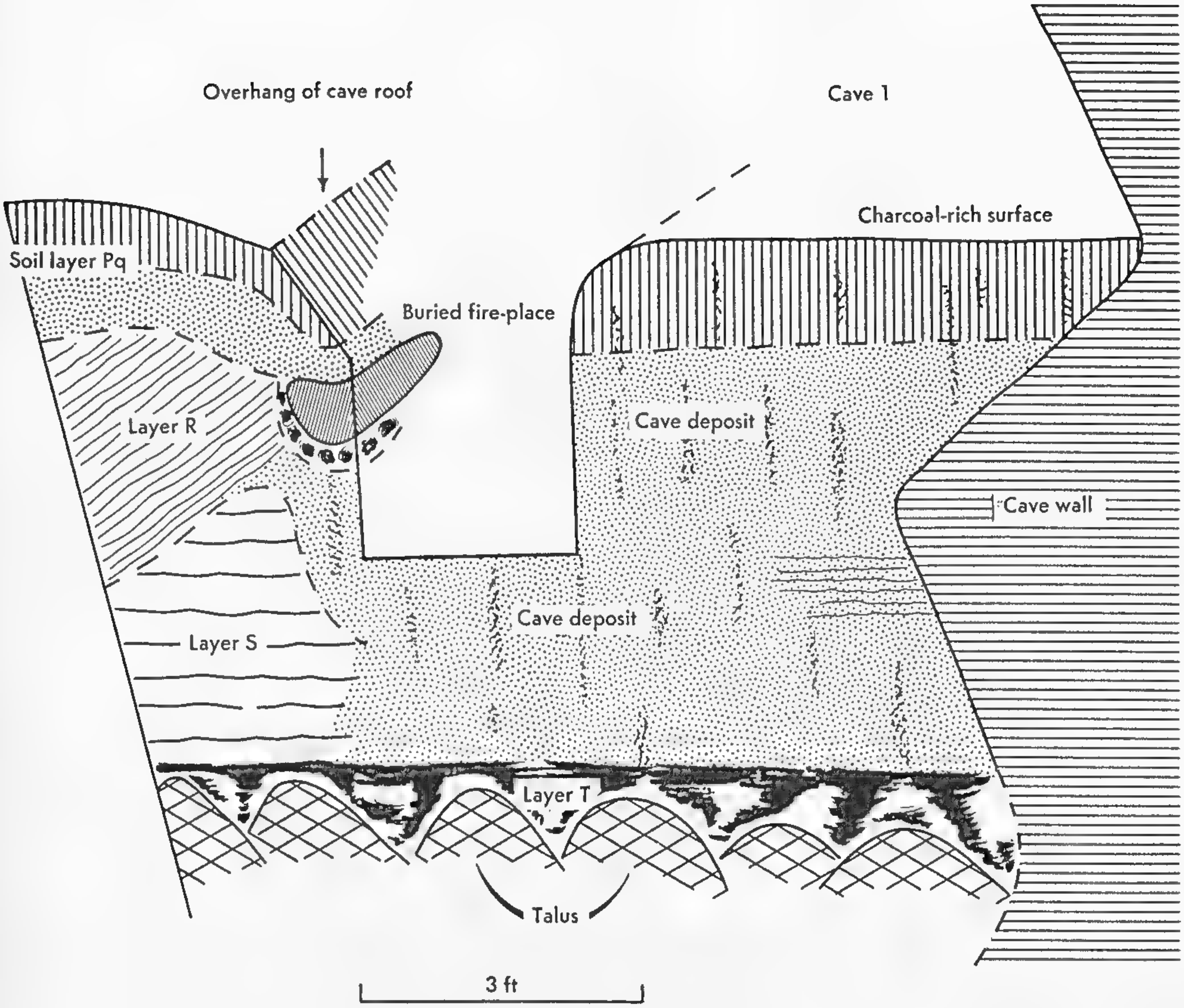
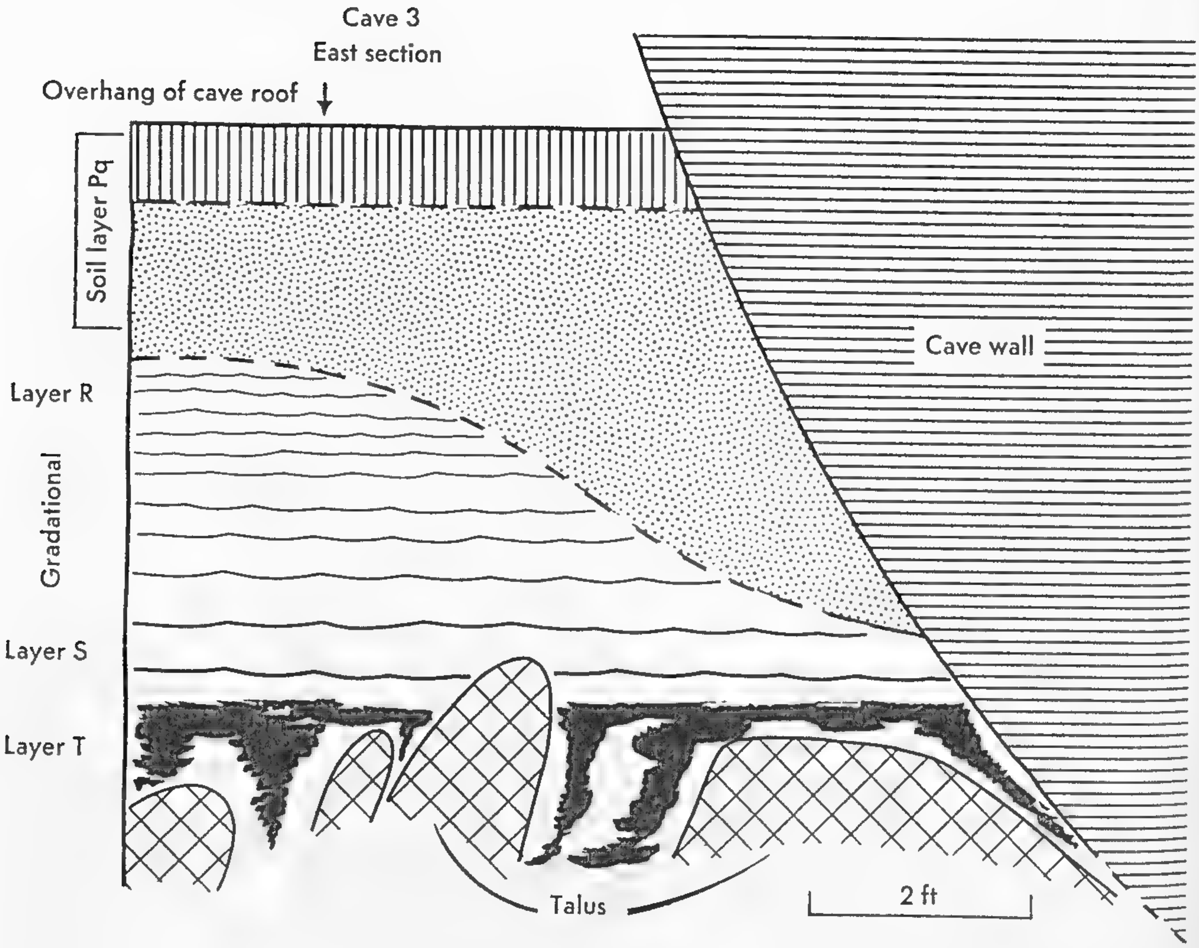
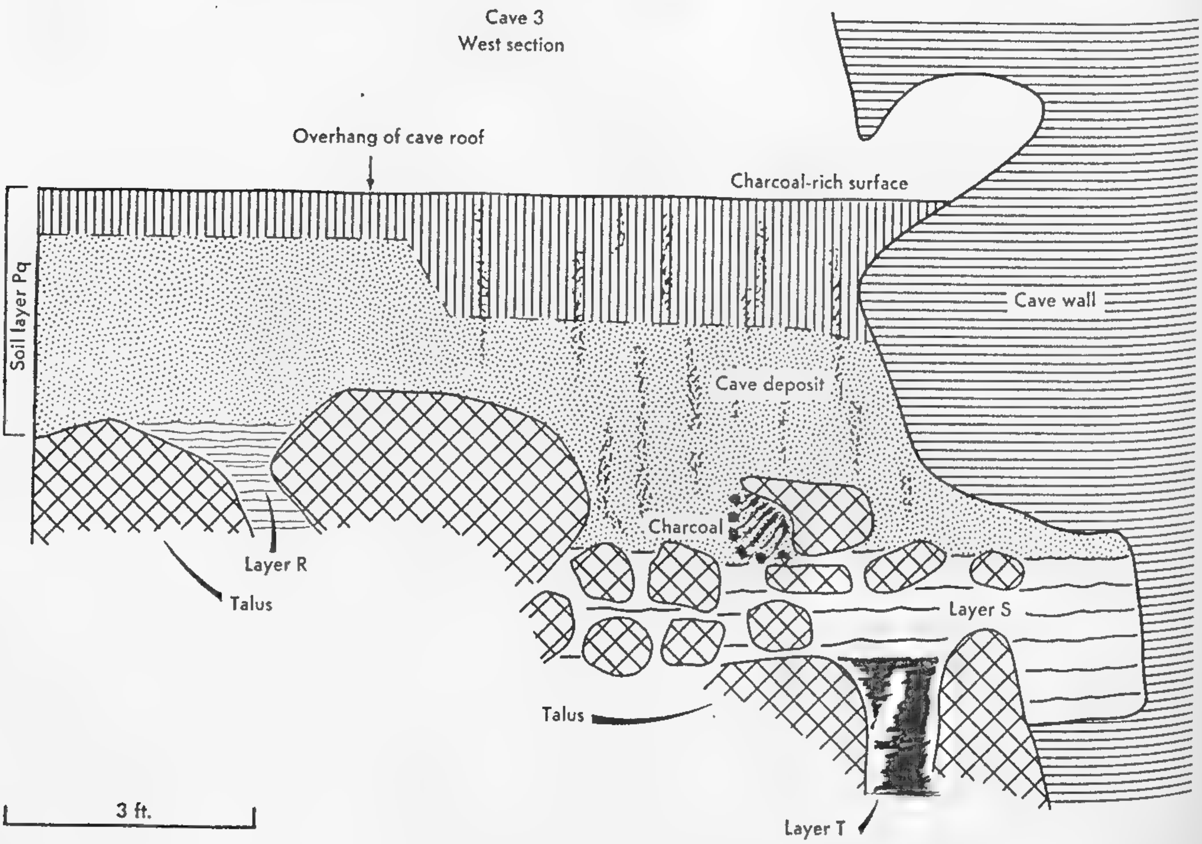


Fig. 8

the subsoil of the upper profile to the genetic C horizon below; Robinson and Rich (op. cit.) also found that the clay bands were aligned with the depositional bedding of unconsolidated deposits. The clay bands within the sandy soil layers R and S at Glen Davis cannot be readily related to those observed in American soils; their position below the shallow, single-grained sandy soil *PQ* to which they are not genetically related is not analogous to the situation proposed for the American soils, where the clay bands are derived from an overlying subsoil of accumulation. In the Glen Davis soils either the overlying subsoil is not an essential part of the system and new clay bands accumulate with each new layer of sediment, or else a B horizon was originally present for each of the layers R and S and has been removed by erosion prior to the development of soil *PQ*.

The presence of parallel-horizontal clay bands of gradually increasing thickness with depth in cave 3 suggests that the processes of deposition of sandy sediment and the development of clay bands has progressed steadily at the site, whereas at the same time unconformities developed at cave 1. Not only is there a marked difference in the angle of inclination of the clay bands in layers R and S at cave 1, but there is also an abrupt boundary between the layers; the thickness of the clay bands changes equally abruptly from thin (1/16 inch) in layer R to thick (1 inch) in layer S. The evidence at cave 1 indicates a pause in the continuity of sediment deposition and





Figs. 9a (top) and 9b

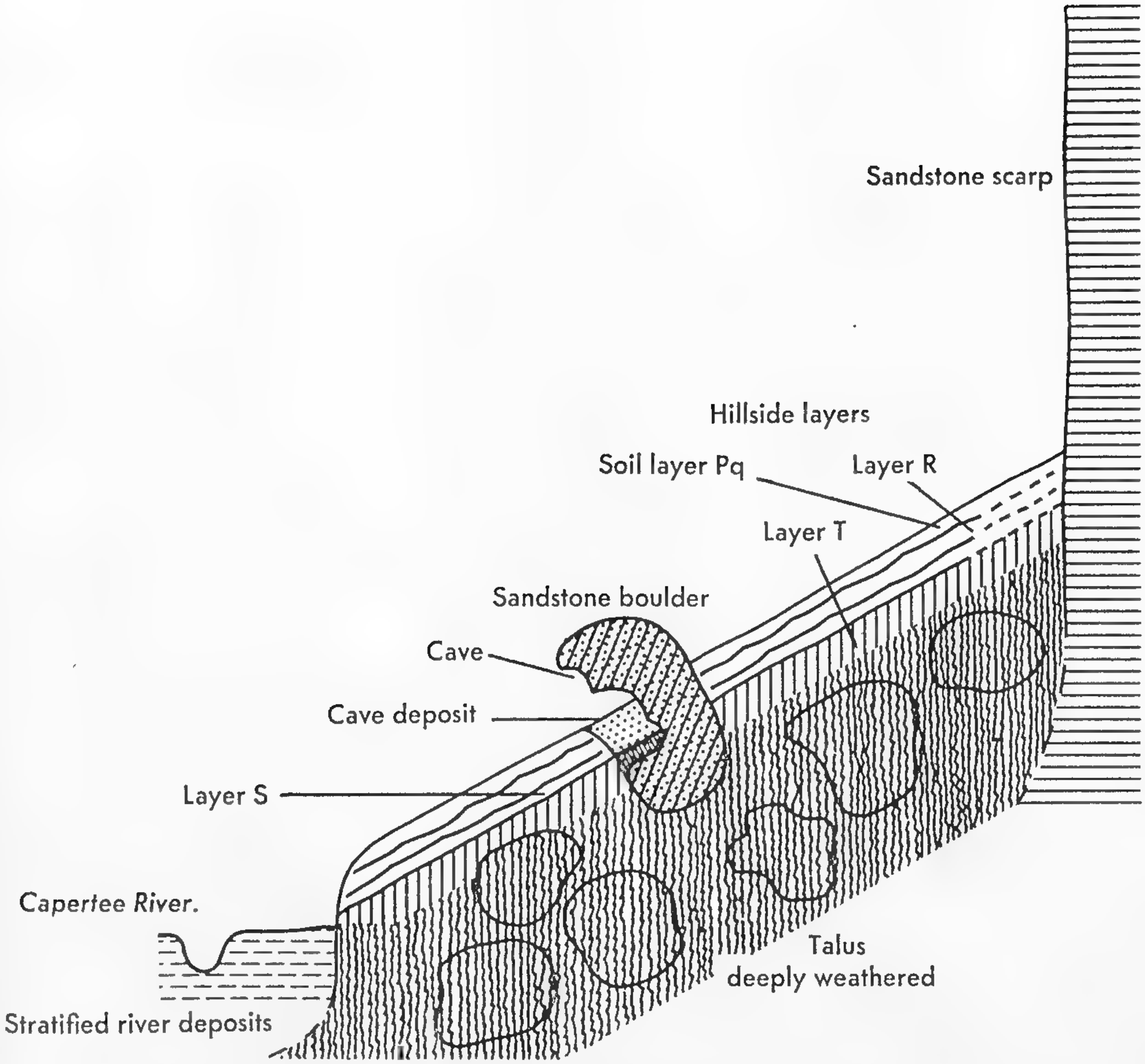


Fig. 10

therefore in the replication of clay bands also, so that soil layer S may represent a phase of localised ground surface stability and soil development in the past, similar to the regional phases of stability described by Butler (1959). There is insufficient evidence to prove layers R and S as parts of separate soil systems; therefore in the following section, while reference is made to R and S as separate entities in the stratigraphic sequence, it is not assumed that they are parts of separate soils, and therefore similar to the periodic soil phenomena described by Butler (op. cit.).

The soil history in the vicinity of the archaeological sites can be elaborated further by considering the relationships of the terrace soils of the Capertee River and the deposits in lateral streams to the soil layers described above. The stratified river terrace deposits are found superimposed on the hillside soil *PQ* and therefore are younger than it. The deposits in the ephemeral stream are also stratified and they overlie the truncated soil *PQ* and therefore are younger than it. Both the main river deposits and the ephemeral stream deposits and their soils represent the latest minor phase of erosional activity which may well be related to clearing and depletion of the vegetative cover since the advent of the white man to Australia.

(iii) Soil chronology

The sequence of sedimentary and soil events described above is the basis of a tentative soil and landscape chronology in Table 1. At least two of the layers, viz., *PQ* and T, have developed as a result of periodic landscape events which are similar in principle to the K-cycles of Butler (1959). Each K-cycle commences with a phase of groundsurface instability during which hillsides are eroded and lose part or all of their soil mantle. In the final stages of instability the sediment in transit across the hillside becomes progressively less mobile until eventually it is stable and soil development starts afresh within the new hillside deposit. A repetition of these landscape and soil events will give rise to a sequence of soil layers, the oldest of which are buried.

At Glen Davis the oldest soil exposed in the archaeological sites is represented by the very coarse talus deposit and its red and sometimes yellow mottled soil (layer T). This soil forms a base layer above which young hillside deposits and soils developed. The materials of layer S were deposited next and were characterized by a coarse sandy and stony mantle over the talus hillside; this deposit was subsequently leached to form thick clay bands. Within cave 1 the deposit contemporaneous with layer S was almost entirely devoid of stone and the first clear evidence of human occupation of the caves is recorded. Subsequent erosion, deposition and leaching gave rise to the sandy and somewhat less stony layer R over the hillside and then followed the last cycle of erosion, deposition and soil formation which gave rise to soil *PQ*. Human occupation of the caves continued throughout these later landscape and soil events and the final phase of river deposition and sedimentation along lateral ephemeral streams brings the chronology to the present day. The sequence of soil layers and cave deposits is shown diagrammatically in figure 10.

The history of the Capertee River Valley is of much greater antiquity than the chronology outlined here. The prolonged period of valley incision which gave rise to the precipitous sandstone gorges of 1,500 feet depth probably dates from the general late Tertiary uplift of eastern Australia which caused all eastern streams to incise their courses. Subsequent to the early lateral corrosion of the river, the retreat of the valley sides has been accomplished by rockfall from the sheer sandstone scarps. The talus so formed is very deeply and intensively weathered, as evidenced by the reticulately mottled red and white clay at the base of the deposits. It is evident then that the hillside and cave events described here are minor surface disturbances of relatively short duration compared with the overall development of the valley.

ACKNOWLEDGMENTS

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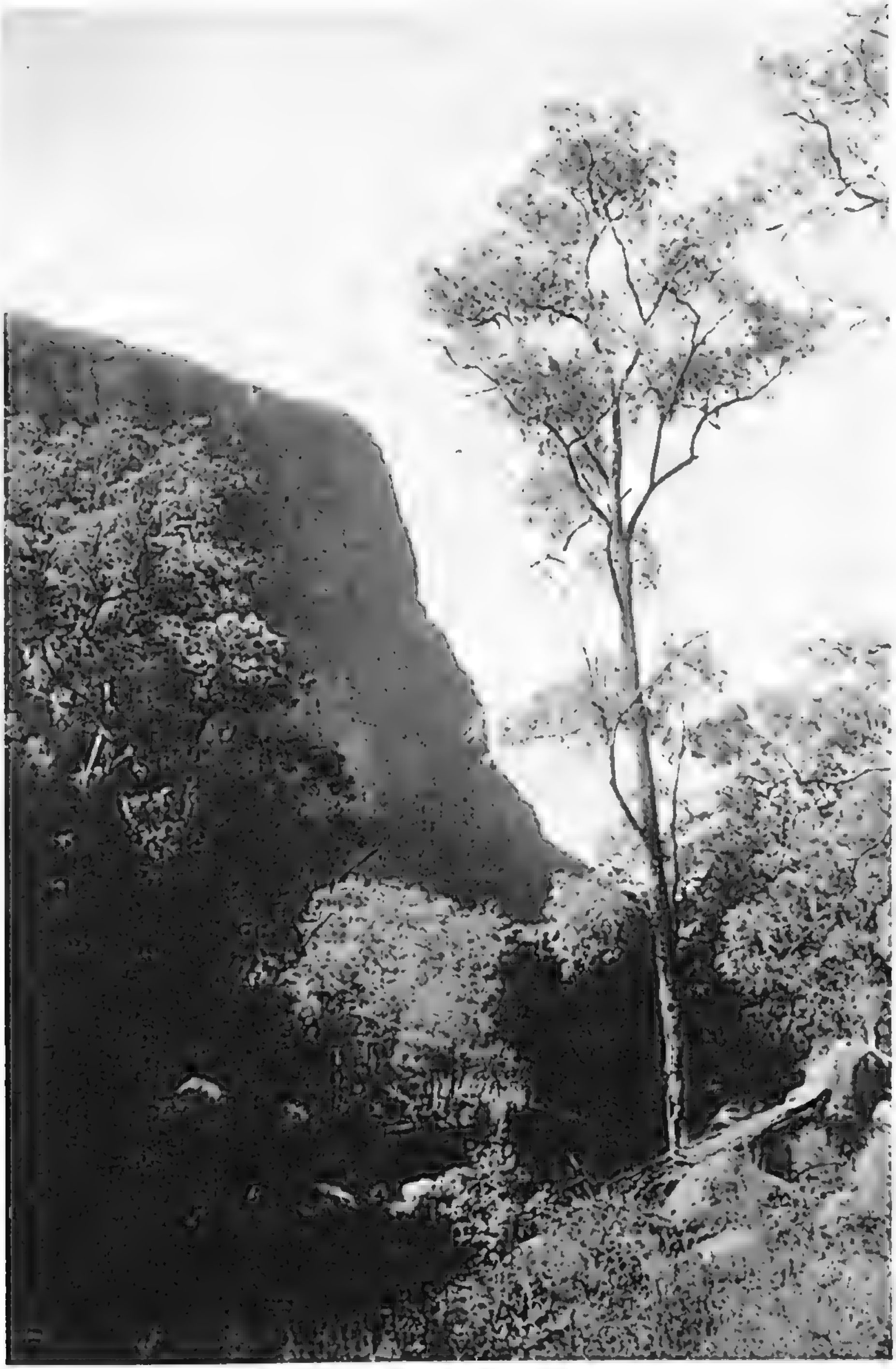
Table 1

A tentative chronology of soil, landscape and occupational events in the vicinity of the archaeological sites

Major Periods	River Phases	Hillside Phases	Cave Phases	Cave Occupation
Present	Deposition of stratified sediments along main river and ephemeral stream courses.	Generally stable.	Some fretting and flaking of cave roof.	
		Deposition of sandy hillside mantle and development of soil layer *PQ* (loose sandy soil).	Deposition of sandy sediment with very few rock fragments; copious charcoal deposited.	Evidence of occupation strong; fire-places, etc.
		Deposition of sandy and stony hillside mantle and development of soil layer R (thin clay bands).	Deposition of sandy sediment with very few rock fragments; charcoal and burnt soil.	Evidence of occupation strong; fire-places, etc.
Late history of Capertee.	Continued entrenchment into talus.	Deposition of sandy and stony hillside mantle and development of soil layer S (thick clay bands) above red talus soil T.	Deposition of sandy sediment in cave 1 and stony sediment in the western part of cave 3; charcoal not readily visible.	Occupation evident in occasional artifacts.
Early history of Capertee valley.	Stream entrenched into talus.	Late talus build-up and weathering to red soil T.	Deposition of sandy sediment in cave 1 above talus to form red and yellow soil layer T.	No occupation.
Late Tertiary.		Build up and intense weathering of talus giving red and white plastic clays.		Pre-man.



The Capertee River, showing the bouldery lower slopes and the precipitous sandstone scarp

Cave 3, showing the scale of the sandstone boulder and cave.

The archaeological excavation at Cave 3, showing the depth of cave deposit and the numerous smaller cavities within the main cave. The string in the foreground lies along the line of the west section of the cave (see figures 6 and 9).

NOTES ON THE GENERA *AMORIA* GRAY, 1855, AND *ZEBRAMORIA* IREDALE, 1924, (GASTROPODA: VOLUTIDAE), WITH DESCRIPTIONS OF NEW SPECIES

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Plate 28. Figs. 1-7 Manuscript received 5-7-63

ABSTRACT

Some notes on the nomenclature, distribution and characteristics of several species of the genera *Amoria* Gray and *Zebramoria* Iredale are given. Two new species of *Amoria* are described from eastern Australian localities.

INTRODUCTION

The genus *Amoria* Gray is one of the most varied groups of the Family Volutidae, with a number of elegant and richly coloured species, distributed around the coasts of Australia. The genus does not extend beyond Australian waters. *Amoria* is a group which appears to be in a state of active evolutionary divergence, as compared with other Volutidae, because of the number and variety of its species, the variation in morphology and wide geographic range of individual species, and the comparative closeness in characters of some pairs of species. A revision of the genus was published by Ludbrook (1954) in which many difficult taxonomic problems were solved, and for the most part her results are still acceptable.

However, recent research at various museums in Australia and overseas has enabled the determination of some points on which Ludbrook was uncertain, while in one or two minor instances her conclusions have been found to be incorrect. Further, the acquisition of much new material in this genus from a number of collectors during recent years has revealed the occurrence of some new species which are described below, and has provided better information on the distribution and morphology of some species. A number of Western Australian volutes were collected by the 1960 Hawaiian-Western Australian Expedition in the M.V. *Davina* and while these included a number of species of *Amoria*, a report on them will be published elsewhere. Particular thanks are due to Mrs. R. Kerslake, Mr. Clifton S. Weaver, Mr. and Mrs. W. Goode, Mr. T. Nielsen and Mr. F. McCamley, for their help in making specimens of animals and shells available for study. For convenience, the species are dealt with in the order adopted by Ludbrook (1954).

Genus **Amoria** Gray, 1855

Amoria Gray, 1855, p. 64. Type species by subsequent designation (Harris, 1897, p. 108). *Voluta turneri* "Gray"=Griffith and Pidgeon.

Subgenus **Amoria** Gray, 1855

Amoria canaliculata (McCoy, 1869)

Voluta (*Amoria*) *canaliculata* McCoy, 1869, (July), p. 34, pl. 3, figs. 1 and 2.

Voluta harfordi Cox, 1869 (September), p. 358, pl. 26, figs. 2a, b.

This species has been rediscovered in recent years by trawling and dredging in waters off Yeppoon and the Keppel Islands, Queensland, and at Lady Musgrave Island in the Bunker Group. Many fine specimens have been collected and these range in colour from pale shells with light reddish lines to deeply coloured pinkish red shells with deep red lines and bold encircling spots. The animal of a specimen from off Keppel Island is reddish purple in colour, with numerous cream spots which run together to leave a reticulation of reddish purple. The siphon is similarly coloured and bears slender, sub-equal appendages, approximately opposite each other. The radula consists of about 300 Y-shaped teeth, which differ from typical *Amoria* teeth in that the cusp is expanded into a blade-like plate, running backwards over the angle of the basal plate (fig. 1).

Amoria maculata (Swainson, 1822)

Voluta maculata Swainson, 1822, p. 11, Id., 1832, pl. 87.

Scaphella caroli Iredale, 1924, p. 258.

This species has long been known as *Amoria caroli*, the latter name having been introduced as replacement for *maculata* Swainson, which was thought to be preoccupied by *Voluta maculata* Meuschen, 1781. Since the latter work has now been placed on the Index of Rejected Works by the International Commission, Swainson's name becomes available once again and must be reinstated [as Weaver (1963) has already indicated].

A. maculata is one of the commonest species of the genus, occurring widely in Queensland, and has been obtained in quantity in recent years by prawn trawlers operating south of Fraser Island, where some fine shells of a salmon pink colour with deep bluish spots were found. Two records which require confirmation have been received at the Australian Museum recently. A young shell was said to have been collected on Woolgoolga Beach in northern New South Wales, while an adult shell was found at Lord Howe Island. Both these localities considerably extend the range of the species which was previously thought to be confined to Queensland north of Wide Bay. Another unusual colour variation has been obtained on St. Crispin Reef, off Cairns, Queensland, in which the spots are elongated into a wrinkled lineation, thus approaching *Amoria volva*. Some shells found on reefs near Cairns are almost completely lacking in the dark spots or maculations so characteristic of most populations of this species. However, in every other way they agree with *A. maculata* and must be regarded as colour variants only.

An animal of this species from 30 fathoms, 12 miles east of Fraser Island, Queensland, is spectacularly coloured in alternating reddish orange and cream radial bands around the edge of the foot, which split and anastomose to some extent on the body; the head is striped longitudinally, while the tentacles and proboscis are cross-striped in the same colour pattern. The siphon bears long appendages, of equal size, and the radula consists of about 137 typically Y-shaped teeth (fig. 2).

Amoria molleri (Iredale, 1936)

Relegamoria molleri Iredale, 1936, p. 314, pl. 23, fig. 10. Garrard, 1961, p. 21.

Garrard has recorded the rediscovery of this species in depths of about 100 fathoms off central New South Wales. Specimens were available for dissection from off Barrenjoey, Broken Bay, New South Wales, collected by Dr. A. Racek on the trawler *Challenge*. The animal is cream in colour, overlain with a lovely salmon pink decoration, in irregular reticulation, mainly parallel to the margin of the foot. The proboscis and siphon are irregularly striped in a longitudinal pattern, while the tentacles are prominently cross-striped with salmon pink. The siphon is rather short, stout, tapering to a point with comparatively long, stout, sub-equal appendages. The radula consists of about 125 typically Y-shaped teeth (fig. 3).

I am in agreement with Ludbrook that the genus *Relegamoria* Iredale should be placed in the synonymy of *Amoria*. Iredale claimed that " the apical whorls distinguish this species from *Amorena*, and also from *Amoria*, though it seems nearer the latter tropical genus than the former, the local genus of southern Australia ". Iredale failed to elaborate this statement, and I can see no significant difference between *molleri* and other species of *Amoria s.s.*, least of all in apical characters, while the radula is typical of *Amoria*.

Amoria spenceriana (Gatliff, 1908)

Voluta (*Amoria*) *spenceriana* Gatliff, 1908, p. 84, pl. 4.

This remains a rare species, known only from a few poorly localized specimens. While its colour pattern of a few dark, irregular markings on creamish-white shell is not outstanding, the species is exceptional in possessing only three columellar plaits. Apart from the specimens listed by Ludbrook, I noted only one additional specimen in the Museums visited by me. This was in the Royal Scottish Museum, Edinburgh.

Amoria volva (Gmelin, 1790)

Voluta volva Gmelin, 1790, p. 3457, based on Chemnitz, 1788, p. 143, pl. 148, figs. 1389-1390.

This species remains an enigma, as its identity and location are still uncertain. After centuries of misidentification, Ludbrook examined the Chemnitzian type and stated that it was not the Western Australian species now known as *grayi*, but was a species " close in shape to *A. turneri* and somewhat similar in colour pattern to *A. caroli* (Iredale). The small species *A. praetexta* also resembles *volva* in its colour pattern." Ludbrook speculated that the locality of the species might be New Guinea or north Australia, possibly Cooktown. The latter suggestion derives from the fact that any Queensland shells which reached Europe prior to 1800 must have been collected by Cook's expedition, making Cooktown and Possession Island, Torres Strait, likely localities. The British Museum specimens reported by Ludbrook have been examined and they do appear to represent a distinctive species, with a close relationship with *Amoria maculata* (*caroli* olim). Should the two species prove to be synonymous, *volva* would have priority.

Ludbrook was incorrect in considering *Amoria grossi* Iredale, 1927, to be a gerontic specimen of *Amoria volva*. It has since been shown to be a distinctive species of the genus *Volutoconus* Crosse (see Abbott, 1958 and McMichael, 1960).

Amoria dampieria Weaver, 1960

Amoria (*Amoria*) *dampieria* Weaver, 1960, p. 1, 3, figs. 6 and 7, ex Cotton, 1949, p. 191, m.s. ("*Zebramoria zebra dampieria* Iredale").

It is necessary to clear up some of the confusion surrounding the name *Amoria* (or *Zebramoria*) *dampieria*. This name first appeared in literature in Cotton (1949, p. 191) and subsequently was listed again by Cotton (1957). On each occasion, it was attributed to Iredale, 1914, as a subspecies of *Zebramoria zebra* from Western Australia. Cotton has subsequently stated (pers. comm.) that he copied the name from labels in the South Australian Museum collection, though the actual source of these labels is not certain. No such name was ever published by Iredale, though he did record the species "*Zebramoria zebra* var." from the Montebello Islands, Western Australia (1914, p. 674). Iredale's specimens cannot be located now and their identity is uncertain. It seems unlikely that any specimens of *Zebramoria zebra* have ever been found in Western Australia, since the known range of the species is from eastern Victoria to south Queensland. During 1960, the Hawaiian Western Australian expedition in the yacht *Davina* collected many volutes from coastal waters of southern Western Australia, and among these was a small, striped volute which was at once identified with Cotton's "*dampieria*". I supplied information on the status of the name to Weaver, who was reporting on the collections in a series of articles in *Hawaiian Shell News*. Through a misunderstanding, Weaver published a photograph of a specimen of the shell together with a caption including the name "*Amoria* (*Amoria*) *dampieria* Iredale, 1914, nomen nudum". In addition, he gave the locality, measurements, and, on a subsequent page, brief descriptive notes. Since this publication appears to fulfil the conditions of availability (International Code, Articles 11 and 13) the name must date from this usage with Weaver as author. In order to regularize the matter, Weaver has agreed to republish the name with a proper description elsewhere. [*J. Malac. Soc. Aust.*, 7, pp. 28-31, 1962].

Amoria guttata sp. nov.

Pl. 28, top two figs.

Description: Shell of moderate size, slender, with short, conical spire, large body whorl, slightly shouldered, sutures only slightly impressed. Protoconch of $3\frac{1}{2}$ whorls, smoothly conical, polished and without sculpture; fawn coloured, with a white sutural band; slightly offset from the two adult whorls. Shell brown, with four darker brown encircling bands, and generally overlain with white markings; darker bands in positions as follows—one subsutural, one at shoulder, one half-way between shoulder and anterior end of shell, and one at the anterior end; white markings irregularly arranged, average size about 2 mm. by 1 mm., elongated in an anterior-posterior direction, and concentrated in the areas between the darker bands, though a few larger, spaced markings occur in the bands. Aperture slender, bluish-white, outer lip margined with light brown, inner lip with a thin glaze obscuring the colour pattern of the previous whorl; four strong, columellar plaits, the third from the anterior end continuing as the upper edge of the fasciole. Animal unknown.

Dimensions.—Holotype: Length 54.5 mm., maximum diameter 22 mm., length of aperture 41 mm. Paratype: Length 53 mm., maximum diameter 21 mm., length of aperture 37 mm.

Types and Type Locality: The holotype is in the Australian Museum, No. C. 63998, and a paratype is in the collection of Mr. C. Coucom, of Yeppoon, Queensland. Both shells were dredged by Mr. Tom Nielsen, of Yeppoon, in about 20 fathoms south of Cairns, Queensland.

Remarks: This is undoubtedly one of the most beautiful shells which have been found in recent years, and it is remarkable that such an elegant shell should have escaped detection until now. The description given applies only to the holotype, which is a recently-dead shell in good condition. The paratype is a worn shell, but otherwise agrees in most details. Two additional shells which are considered to be referable to this species have been seen. One, in the collection of Mr. R. Brown, of Yeppoon, Queensland, is a dead shell, trawled off Yeppoon, which bears a general resemblance to *Amoria guttata* in shape, size and colour, but differs in details of pattern. The colour is somewhat lighter, and the white linear markings are much larger, longer, and most extend right across the areas between the slightly darker bands. Some are continuous with the white markings on the bands, thus yielding a continuous white stripe which may be more than 20 mm. long. A second specimen, almost identical with Brown's shell, but somewhat discoloured through decomposition, is in the collection of Mr. J. Feros, of Evan's Head; it was dredged in 11 fathoms off South Keppel Island, Queensland. It may prove that these two shells are members of a species distinct from *A. guttata*, or they may represent a geographic subspecies. A decision must await the acquisition of a range of specimens.

Subgenus **Amorena** Iredale, 1929

Amorena Iredale, 1929, p. 180. Type species by original designation *Voluta undulata* Lamarck.

Amoria (**Amorena**) **undulata** Lamarck, 1804

Voluta undulata Lamarck, 1804, p. 157, pl. 12, figs. 1a, b.

Voluta angasii Sowerby, 1864, p. 271, based on Sowerby, 1844, pl. 48, fig. 29.

Voluta (Amoria) australiae Cox, 1871b, p. 643, pl. 52, fig. 1.

Scaphella moslemica Hedley, 1912, p. 145, pl. 43, figs. 29 and 30.

This is the commonest species of *Amoria*, extending from south Western Australia to central New South Wales, in shallow depths on the continental shelf. There is a notable amount of variation in shape, especially in the degree of shouldering, and the ground colour varies from almost white to deep orange-brown, with reddish-brown lines of fairly consistent pattern. The name *angasii* Sowerby (sometimes incorrectly attributed to Brazier) was given to the Tasmanian form of the species in the belief that it differed from the South Australian population, and some authors have attempted to use the names *undulata* and *angasii* as geographic races from South Australia and Tasmania respectively. However the type locality of *Voluta undulata* Lamarck is "Bass Straits and Maria Island, Tasmania" so that *angasii* is synonymous. In any case, there is no significant difference between shells from the two areas, apart from the generally deeper colouring of the Tasmanian shells, so that racial differentiation is not warranted.

The status of two forms listed by Ludbrook as synonyms without comment, viz. *australiae* Cox and *moslemica* Hedley, must be re-examined. The holotypes of both species are in the Australian Museum as well as several paratypes of *moslemica*. The latter came from a depth of 250 fathoms and was differentiated because of its "smaller, thinner shell with a smaller protoconch and having the spire whorls wrapped in a white sheet of callus". It is certainly true that shells from deep water off the New South Wales coast are more slender and less shouldered than southern forms, but this seems to be merely a function of latitude. The pattern of lines is identical with that of typical *undulata*, and the only character which might otherwise serve to differentiate *moslemica* (the white apical callus) is apparently a deep-water effect,

since shells from about 60 fathoms have the glaze partly developed, while those from about 40 fathoms lack it completely. Consequently, I regard *moslemica* as a deep-water ecophenotype only and agree with Ludbrook in relegating it to the synonymy of *undulata*.

The type of *V. australiae* Cox agrees with *A. undulata* in every way, except for the pattern of the brown lines. No shell identical with it has ever been found to my knowledge. It measures 60 mm. long and 27 mm. in maximum diameter, agreeing exactly with Cox's original figure, of which Tryon's (1882, pl. 26, fig. 73) and Sowerby's figures (1887, fig. 151) are both poor copies. Cox (1872, p. 16) suggested the Ninety Mile Beach, Victoria as its true locality. Two shells have recently been found by Mr. Neil Buckland on beaches near Eden, New South Wales. These are generally similar to Cox's type, but the number of longitudinal lines is less, and they are short, and not continuous for the full length of the body whorl. Radular teeth from one of these specimens (fig. 4) are similar to those of typical *A. undulata*, which has about 135 typically Y-shaped teeth (fig. 5). A third fully adult specimen from near Eden, in the collection of Mrs. W. Gilfillan, has similar markings but at the last portion of the body whorl near the outer lip and on the colemellar lip of the aperture it displays the typical markings of *A. undulata*. It seems clear that these shells, as well as the type of *V. australiae* Cox, are mutants or aberrant colour forms only, and so *V. australiae* is correctly placed in the synonymy of *Amoria undulata* (Lamarck).

The animal of *Amoria undulata* is cream, with a reddish pattern of generally radiating lines, anastomosing and splitting, but fairly widely spaced. The head has two very large tentacles, large lateral lobes with prominent eyes. The siphon is stout, muscular, with large flattened appendages of equal size.

Amoria (Amorena) sclateri (Cox, 1869)

Voluta sclateri Cox, 1869, pp. 358-359, pl. 26, fig. 3.

Voluta kingi Cox, 1871. p. 324, pl. 34, fig. 4.

The types of the two nominal species have been examined, and I agree with Ludbrook that they are synonyms, and that the species is distinct from *A. undulata*, though undoubtedly derived from it. Numerous pallid specimens of *A. undulata*, with the orange-brown lines scarcely visible, have been distributed to collectors as *A. sclateri*. However, the latter has no trace of coloured lines whatever, and its colour is usually a pale cream to white.

Amoria (Amorena) exoptanda (Reeve, 1849)

Voluta exoptanda Reeve, 1849, pl. 10, fig. 22.

This well defined species was omitted by Ludbrook from her revision. It is still very rare, only a few specimens being known and these seldom perfect. Localities from which it has been recorded are as follows: Encounter Bay (Cotton, 1957), Yankalilla Bay (Aust. Mus. C30048), Port Lincoln (British Mus., Holotype), Middleton (U.S. Nat. Mus. 612466, Aust. Mus. C62133. All South Australia. A perfect specimen is in the National Museum of Victoria, unfortunately without precise locality...

Amoria (Amorena) benthalis sp. nov.

Pl. 28, bottom two figs.

Description: Shell small, robust, with short spire, the apex bluntly rounded, the suture glazed over; body whorl large, weakly shouldered. Protoconch of 2 whorls, smooth, highly polished, uniform creamish-brown, adult whorls 2½, colour cream, with an ill-defined brown band just beneath the suture and two spiral bands of brown spots, one at the shoulder and one half-way between this and the anterior end of the shell, and with numerous fine, longitudinal reddish-brown lines spaced about 1 or 2 mm. apart, slightly undulating, with two peaks at the positions of the bands of brown spots; anterior end of shell suffused with brown. Aperture gaping, white to orange, with four strong plaits; fasciole weakly developed. Animal unknown.

Dimensions:

	Length	Maximum Diameter	Length of Aperture
Holotype	35.0 mm.	16.5 mm.	26.5 mm.
Paratype	29.5 mm.	15.0 mm.	23 mm.

Type Locality: 120 to 125 fathoms, off Cape Moreton, Moreton Island, Queensland.

Types: The holotype is in the Australian Museum, No. C. 63999, and paratypes are in the Australian Museum and the Bernice P. Bishop Museum, Hawaii.

Remarks: The new species resembles *A.* (*A.*) *undulata* in possessing undulating longitudinal lines of colour, but the undulations are not so acutely angled as in that species. In addition, the spiral bands of brown spots are not present in *A. undulata*, which is larger and does not range further north than Port Macquarie, New South Wales. The shells were trawled by Mr. W. Goode, of Redcliffe, Queensland; Mr. C. S. Weaver, of Honolulu, Hawaii, has kindly presented a fine specimen of this shell to the Australian Museum, which has been chosen as the holotype, while Mrs. R. Kerslake presented the two paratypes. One of the paratypes has the anterior end broken and could not be measured. Both are a little more squat and strongly shouldered than the holotype.

Genus **Zebramoria** Iredale, 1929

Zebramoria, Iredale, 1929, pp. 180 and 189. Type species by original designation, *Voluta zebra* Leach.

Remarks: Ludbrook ranked *Zebramoria* as a subgenus of *Amoria*, but the protoconch of both known species is so distinctive being elevated, pupiform, of several rounded whorls, that I regard the group as worthy of full generic rank. An earlier name for this genus is *Pilidia* Valenciennes (1863, p. 72) with type species by monotypy, *Voluta zebra* Leach. However, as the name is not recorded in Neave's *Nomenclator Zoologicus*, and has not been used by any subsequent author, it is a *nomen oblitum* and must be rejected under Article 23b of the International Code.

Zebramoria lineata (Leach, 1814)

Voluta lineata Leach, 1814, pl. 12, fig. 2.

This species has been clearly differentiated by Ludbrook from *Zebramoria zebra*, the radial ribbing of the spire of *lineata* being diagnostic. Ludbrook noted that there was a light colour variant in which the longitudinal lines were reduced or absent, and specimens of this form have been found commonly in Port Curtis in recent years. However, they do not represent a geographic race but are simply colour variants of no taxonomic significance. A specimen of this species from Dundowran, Queensland, was available for dissection, but as it was withdrawn deeply into the shell, it could only be extracted in pieces. The general coloration is of deep reddish black markings on a cream ground colour. Few details of the structure were obtained. The radula was extracted, however, and proved to have 130 Y-shaped teeth, similar to those of *Amoria* (fig. 6).

Zebramoria zebra (Leach, 1814)

Voluta zebra Leach, 1814, pl. 12, fig. 1.

Marginella radiata Lamarck, 1822, p. 356.

Voluta stragulata Schubert and Wagner, 1829, p. 11, pl. 217, fig. 3033.

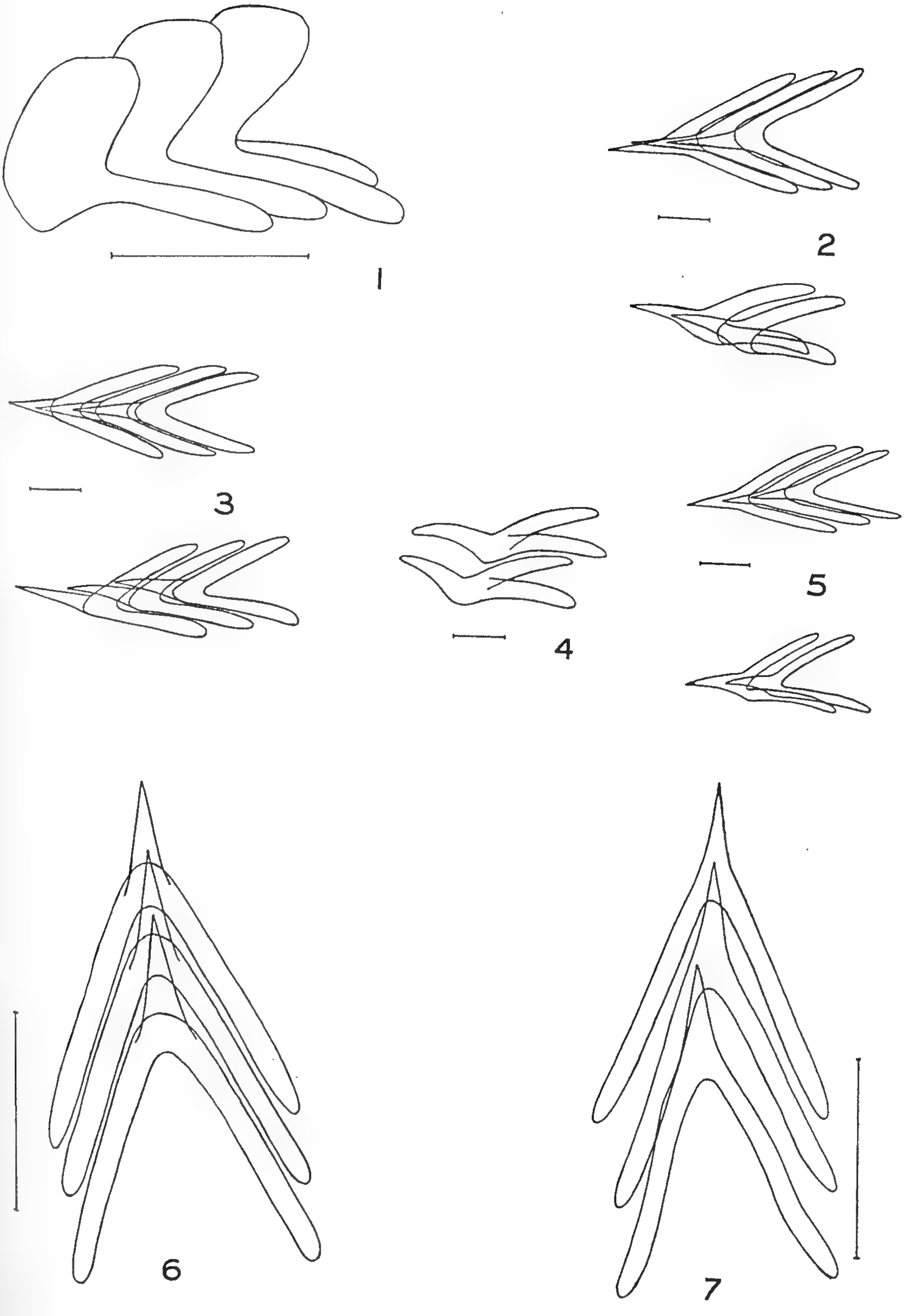
The determination of *Voluta stragulata* as a synonym of this species is somewhat doubtful as the figure is very poor; however, the description, shape and size indicate that it is a *Zebramoria*, and it may well be *Z. zebra*. A specimen was available for dissection, trawled off Southport, Queensland. The foot is small, banded with fine, red stripes, branching and anastomosing on a cream background. The siphon is similarly coloured and bears long equal appendages. The head is rather small, with long thin tentacles. The radula consists of 153 Y-shaped teeth (fig. 7).

→

EXPLANATION OF FIGURES

Radular teeth of *Amoria* and *Zebramoria*. The line adjacent to each figure represents a length of 0.1 mm.

Fig. 1. *Amoria canaliculata* (McCoy). Off South Keppel Island, Queensland.
Fig. 2. *Amoria maculata* (Swainson). East of Fraser Island, Queensland.
Fig. 3. *Amoria molleri* (Iredale). Off Barrenjoey, Broken Bay, New South Wales.
Fig. 4. *Amoria undulata* (Lamarck). Beach near Eden, New South Wales.
Fig. 5. *Amoria undulata* (Lamarck). Off Barrenjoey, Broken Bay, New South Wales.
Fig. 6. *Zebramoria lineata* (Leach). Dundowran, Queensland.
Fig. 7. *Zebramoria zebra* (Leach). Off Southport, Queensland.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EXPLANATION OF PLATE

Top: *Amoria guttata* sp. nov. Holotype, Aust. Mus. C.63998.

Bottom: *Amoria (Amorena) benthalis* sp. nov. Holotype, Aust. Mus. C.63999.

G40952

Rediscovery of the Echinoid *Clypeaster tumidus* (Tenison-Woods) and an Emended Description

By R. Endean, Department of Zoology, University of Queensland, and Elizabeth Pope, The Australian Museum, Sydney

Plates 29 and 30. Figs. 1-7. Manuscript received 31.7.63

In 1878 Tenison-Woods described under the name *Echinanthus tumidus* an echinoid which was housed in the Australian Museum and which was believed to have come from the coast of New South Wales. The specimen was damaged in the region of the actinostome and the test was almost devoid of spines. Holes had been bored through the actinal surface, possibly with a view to mounting the specimen on a board. Bell (1884, plates II and III) amplified Tenison-Woods's brief description and erected a new genus, *Anomalanthus*, to accommodate the species. Subsequently, Mortensen (1948) placed the species in the genus *Clypeaster* but added little to knowledge of the species.

For decades the holotype remained the only representative of the species. Bell (1884) considered the species to be rare and possibly dying out whilst Lambert and Thiéry (1914) considered that the holotype was a fossil, and they attributed it to the Pliocene of Australia. However, in 1960 a specimen was dredged off Ball's Pyramid, Lord Howe Island, in 50-100 fathoms, and in 1961 another specimen was dredged off the coast of southern Queensland. Study of the new material and a re-examination of the holotype have revealed that many of Bell's (1884) statements concerning this species are both erroneous and misleading. In view of this, and also because of the inadequacy of Tenison-Woods's original description, it was decided to redescribe the species and to provide illustrations of the spines and pedicellariae.

The Lord Howe Island and Queensland specimens are illustrated in plates 29 and 30. Measurements for these specimens and for the holotype are as follows:—

Length (mm.)	Width (mm.)	Height (mm.)	Petaloid area (mm.)	Locality	Australian Museum No.
142	120	59	119	N.S.W.?	J. 1348
119	104	59	95	Lord Howe Is.	J. 7300
71	63	28	49	Queensland	J. 7343

Shape

The test in all three specimens is high and the margin elongate ovoid in outline. Both Tenison-Woods (1878) and Mortensen (1948) stated that the holotype is regularly arched. However, in all specimens there is a slight flattening (most pronounced in the Queensland specimen) around the test at the level of the distal ends of the poriferous zones. Thus the tests have short margins. Bell (1884) states that the test slopes " rather more sharply anteriorly than posteriorly ". Actually, the reverse is the case. Angles of slope for the three specimens are as follows:—

Specimen	Anterior	Posterior
Holotype	$46\frac{1}{2}^\circ$	50°
Lord Howe Is. ..	$50\frac{1}{2}^\circ$	$51\frac{1}{2}^\circ$
Queensland ..	43°	44°

The actinal surface is flattened, apart from the region around the actinostome which is deeply sunken.

In the holotype and in the Queensland specimen the sutures between the coronal plates are distinct, but in the Lord Howe Island specimen the sutures are rather indistinct near the margin of the corona.

Ambulacra

The petaloid area is extensive, its length being 0.70-0.84 that of the test length. In each specimen, the postero-lateral petals are the largest and the anterior petal is the shortest. Proximally, the pore pairs of each petal diverge from the apical system and each poriferous zone is V-shaped for slightly over half its extent. Then the two rows of pore pairs of each petal follow parallel courses almost to the distal extremity of each petal. The last one or two pore pairs are usually slightly closer together but each petal remains widely open distally.

Both pores of each pore pair are enclosed and linked by a furrow which is deep and sharply limited. For approximately half the distance along the length of each petal the furrows are oriented at right angles to the long axis of the petal. Distally, the outer pore of each pore pair is set closer to the margin of the test than is the inner pore. This arrangement is accentuated in the case of the last pore pair, and the furrow between these pores is usually curved. An apparent resemblance of the shape of each petal to that of a lyre (Bell, 1884) is the result of an optical illusion stemming from the arrangement of the furrows between the pores and is not borne out by measurements of the intervals between corresponding pore pairs.

The pores down the outer side of each petal are oval in outline and slightly larger than the rounded inner pores. Also, the pores at the distal end of each petal are slightly larger than those near the proximal end. Irregularities in pore size noted by Bell (1884) appear to be mainly due to occlusion of the pores of the somewhat damaged holotype and were not observed in the Lord Howe Island and Queensland specimens.

Distal to the petals small locomotive tube feet are common and they are very numerous in the ambulacral areas of the abactinal surface, particularly near the margin of the test.

On the actinal surface, the ambulacral furrows are well defined for most of their length from the peristome but they become shallower near the margin of the test.

The ambulacral plates widen markedly in the region between the distal ends of the petals and the margin, and at the margin and on the actinal surface the ambulacra are much wider than the interambulacra.

Interambulacra

The interambulacral areas are widest in the region near the distal ends of the petals. As occurs commonly in the Clypeastridae, the adoral interambulacral plate is separated from the following paired interambulacral plates by the interposition of the first two pairs of ambulacral plates.

Tubercles

The primary tubercles are irregularly scattered over the coronal plates but tend to be closer together on the plates near the margin. Those of the actinal surface are larger and more deeply sunken than those of the abactinal surface. The mamelon of each tubercle is highly polished and perforate. Closely packed miliary tubercles fill the spaces between the primary tubercles.

Apical system

The apical system is pentagonal and placed slightly anterior to the centre of the test. It is well covered with miliary spines which are scattered amongst the hydropores. Although Bell (1884) notes differences in the sizes of the five genital pores of the holotype, these differences are again due to occlusion of some of the pores as this area of the test is somewhat worn. After the pores had been cleaned by gentle brushing they were found to be equal in size, as is the case with the genital pores of both the Lord Howe Island and Queensland specimens. Bell also noted that one of the ocular pores of the holotype was enlarged and almost as large as the genital pores. It seems likely, however, that the ocular pore in question has been enlarged by probing. All the slit-like ocular pores are equal in size in the Lord Howe Island and Queensland specimens.

Periproct

The circular periproct is marginal and positioned at an angle of 45° to the actinal surface of the test. It is covered by small plates which bear spines.

Peristome

The peristome is small and deeply sunken.

Primary spines

The primary spines (fig. 1) are fusiform for most of their length but are usually attenuated distally. They are longitudinally grooved and terminate in simple points. In the Lord Howe Island specimen those on the abactinal surface average about 4 mm. in length whilst those on the actinal surface average about 5 mm. in length. The corresponding measurements for spines from the smaller Queensland specimen are 2 mm. and 3 mm. respectively. No spines are now associated with the holotype.

Miliary spines

Each miliary spine (fig. 2) is finely thorny throughout its length. The lengths of those from the abactinal surface average 1.1 mm. in the case of the Lord Howe Island specimen and 0.85 mm. in the case of the Queensland specimen, whilst those from the actinal surfaces average 1.2 and 0.75 mm. respectively.

Pedicellariae

Tridentate pedicellariae (fig. 3) are common on both actinal and abactinal surfaces of the Lord Howe Island and Queensland specimens. However, they are larger on the actinal surfaces of each specimen and their valves average 0.8 mm. in length. Each blade is slender and straight and the edges of the distal part are finely serrate.

The ophicephalous pedicellariae (figs. 4, 5, 6) are common on the abactinal surfaces but somewhat rare on the actinal surfaces of the two specimens. Their valves average 0.4 mm. in length. The spines on the lower part of each blade are strongly developed but the ophicephalous pedicellariae are of the usual shape and not especially characteristic.

The triphyllous pedicellariae (fig. 7) appear to be confined to the actinal surfaces. The valves of these pedicellariae average 110μ in length and are minutely serrated around their edges.

Occurrence

There is doubt as to the locality from which the holotype was secured but it is believed to have come from the N.S.W. coast. The Lord Howe Island specimen was dredged from 50-100 fathoms off Ball's Pyramid (22/11/1960) by Dr. J. MacIntyre,

of the C.S.I.R.O. Fisheries Section (Station G 3/255/60). The Queensland specimen was dredged (7/6/1961) from 20 fathoms seaward of Stradbroke Island (Lat. 27° 31′ S.) by Professor W. Stephenson.

The discovery of these additional specimens dismisses Lambert and Thiéry's (1914) theory that the holotype was fossil in origin, and places *C. tumidus* as an inhabitant of the continental shelf off the eastern coast of Australia. Its range extends eastward at least as far as Lord Howe Island. Further dredging will undoubtedly result in the collection of more specimens and there is no evidence to support the statement of Bell (1884) that the species is rare and possibly dying out.

Colour

The Queensland specimen possesses a light-brown test and the primary spines are white. The dried test of the Lord Howe Island specimen is a darker chocolate brown and its primary spines are white, tipped with brown. The test of the holotype is faded brown or khaki.

Growth changes

Although the Queensland specimen is less than half the size of the holotype it possesses well developed genital pores and is undoubtedly adult. Judging from measurements of the tests of the three specimens available, it seems that the value of the ratio $\frac{\text{height}}{\text{length}}$ increases with age. (It is assumed that the largest specimen is the oldest). Also, the degree of swelling of the test seems to be related to age. The tests of the holotype and Lord Howe Island specimen are markedly swollen whereas the smaller Queensland specimen gives only slight indication of this swelling.

The number of primary tubercles on the ridges between the paired pores of the poriferous zones increases with age. Thus there is one (occasionally two) primary tubercle on these ridges in the case of the Queensland specimen, whilst in the Lord Howe Island specimen the number varies between one and three and in the holotype from one to five.

The size and number of primary tubercles elsewhere on the test seem to increase with age, and probably the dimensions of the primary spines attached to these tubercles increase also. Those from the Lord Howe Island specimen average twice the length of those from the Queensland specimen.

Relationships

Bell (1884) considered that the specimen which Tenison-Woods named *Echinanthus tumidus* differed sufficiently from other clypeastrids to warrant the erection of a new genus, *Anomalanthus*. In his definition of the genus Bell stated that " the ambulacral pores are arranged in rows which are not closed or quite parallel, but which tend to spread out after a lyre-shaped fashion at their distal end ". However, the two rows of pore pairs at the distal end of each petal do not spread out after the manner of a lyre but are essentially parallel. Amongst the fossil clypeastrids are found many species in which the pore series of each petal are parallel or diverge distally. In some recent species similar arrangements of the pore series are found. Accordingly, *Clypeaster tumidus* cannot be separated from all other clypeastrids solely because of the shape of its petals.

When defining the genus *Anomalanthus*, Bell (1884) also stated that the actinal surface is free of pores, that the ambulacral grooves on the actinal surface are inconspicuous, that the genital pores are of unequal size and that the tubercles are regularly distributed over the whole test. These statements are all erroneous. Bell stated further that one ocular pore is enlarged. Although one of the ocular pores

in the holotype is enlarged, this enlargement is probably due to probing. Bell's statement that the primary tubercles are perforate could apply to any clypeastrid. Indeed the only valid feature mentioned by Bell in his definition of the genus *Anomalanthus* which could conceivably be used as a basis for generic distinction concerns the marginal position of the periproct. The only other clypeastrid with a marginal periproct is *Clypeaster europacificus* (Clark) but in this species the periproct is set in a distinct notch. However, none of the other structural features of *C. tumidus* is especially characteristic and it appears unwise to give *C. tumidus* a new generic rank principally because of the marginal position of its periproct. Indeed, Mortensen (1948) after taking cognizance of the great polymorphism exhibited by both fossil and recent clypeastrids placed all of them in the genus *Clypeaster*.

Bell (1884) considered that *C. tumidus* was a primitive form unable to compete with organisms which were " more plastic and more easily adaptable and adapted to the conditions of their present environment ". Clark (1914) thought that discovery of further specimens would throw light on the phylogeny of clypeastrids. According to Mortensen (1948), the most primitive clypeastrids are those with straight pore series and, in this respect, *C. tumidus* may be primitive. However, the structural features of *C. tumidus*, with the possible exception of the marginal position of the periproct, are not especially characteristic nor do they throw light on the phylogeny of clypeastrids, and there appears to be no valid reason why *C. tumidus* should be removed from the genus *Clypeaster*. On the other hand, it does not appear to be closely allied to any of the fossil species and it possesses a combination of structural features which enable it to be separated readily from any of the recent species.

Definition of species

The species may be defined as follows:—

Large form of elongate ovoid outline, high test with short margin, apical system anterior to centre of test, petals widely open and only slightly sunken, distal ends of pore series of each petal parallel and reaching almost to margin of test, peristome deeply sunken, periproct marginal.

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EXPLANATION OF FIGURES 1-7

Fig. 1. Primary spine from oral surface of Lord Howe Island specimen.
Fig. 2. Miliary spine from oral surface of Queensland specimen.
Fig. 3. Valve of tridentate pedicellaria of Queensland specimen.
Fig. 4. Valve of ophicephalous pedicellaria of Queensland specimen.
Fig. 5. Valve of ophicephalous pedicellaria of Queensland specimen.
Fig. 6. Valve of ophicephalous pedicellaria of Queensland specimen, side view.
Fig. 7. Valve of triphyllous pedicellaria of Queensland specimen, side view.

EXPLANATION OF PLATE 29

Clypeaster tumidus (Tenison-Woods)

Fig. 1. Oral surface of the Lord Howe Island specimen (length 119 mm.).
Fig. 2. Aboral surface of the Lord Howe Island specimen.

EXPLANATION OF PLATE 30

Clypeaster tumidus (Tenison-Woods)

Fig. 1. Side view of the Lord Howe Island specimen.
Fig. 2. Side view of the Queensland specimen (length 71 mm.).
Fig. 3. Aboral surface of the Queensland specimen.

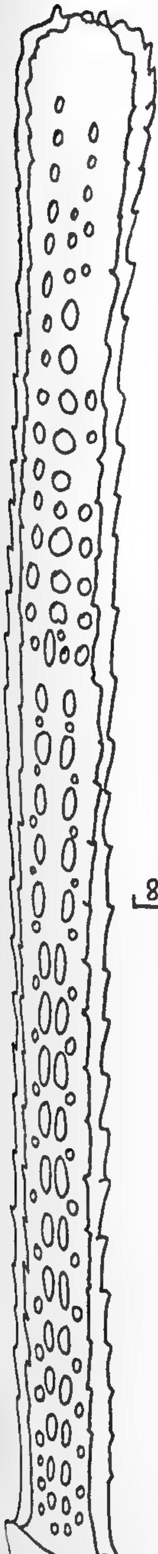


Fig. 2

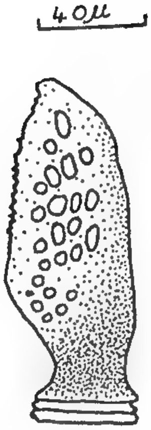


Fig. 7

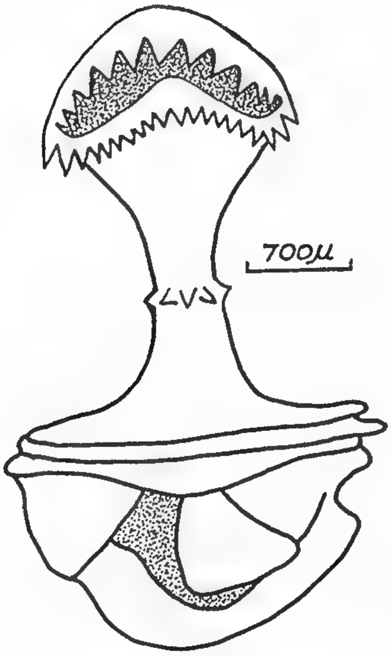


Fig. 4

Fig. 6

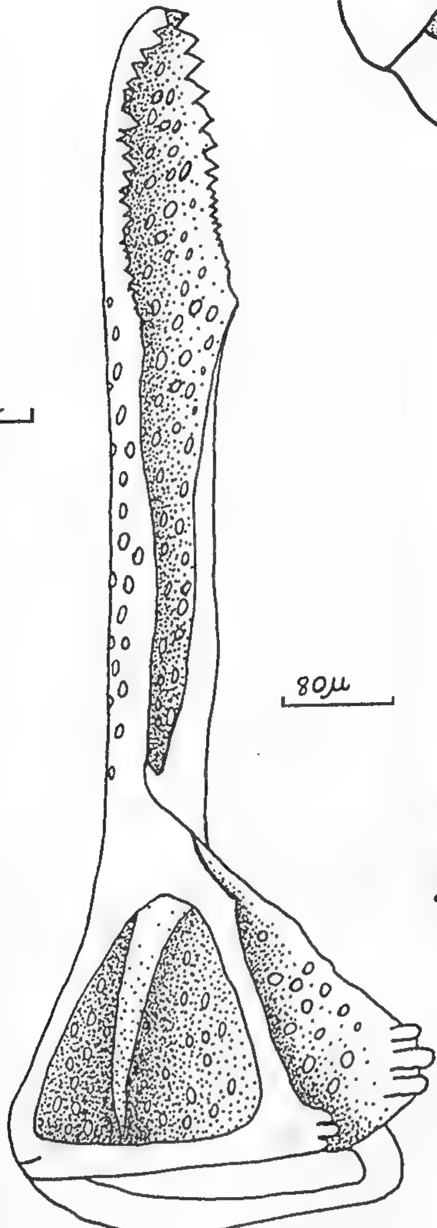


Fig. 3

Fig. 1

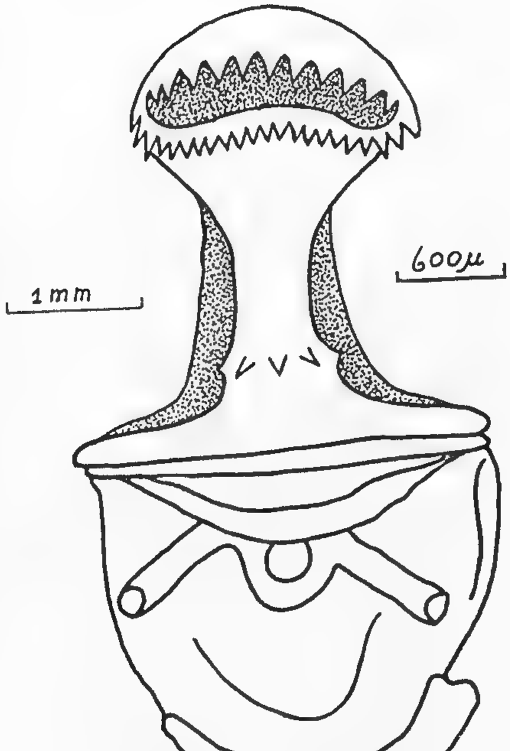
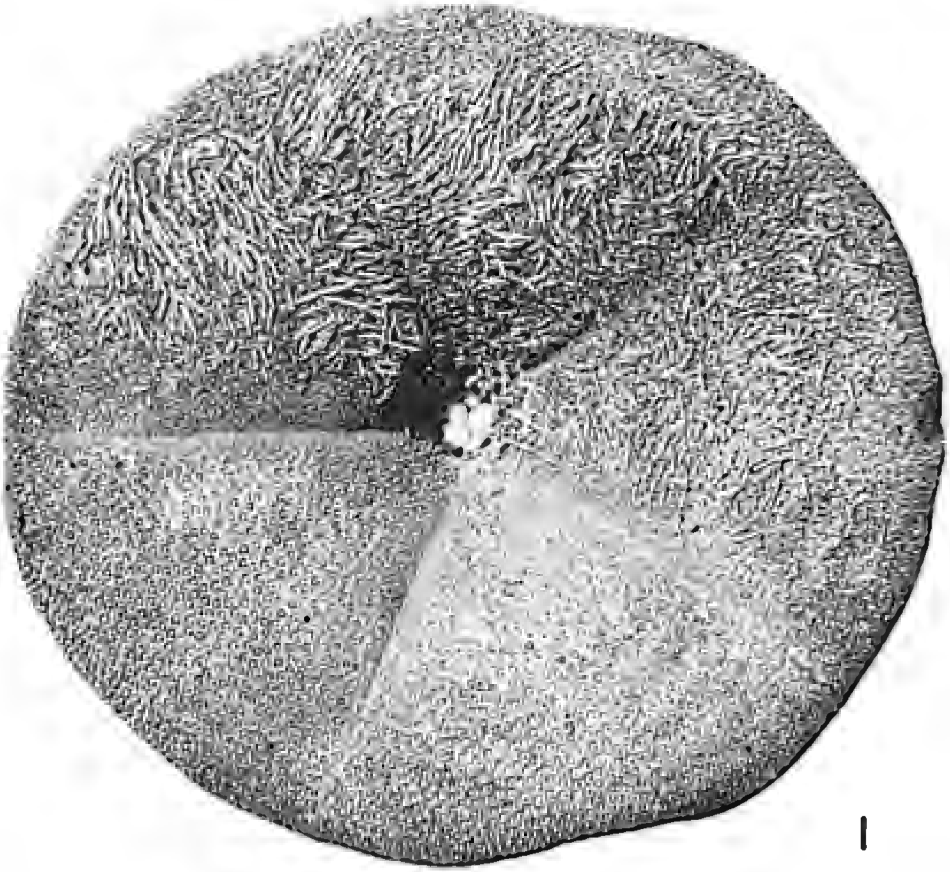


Fig. 5

Figs. 1-7



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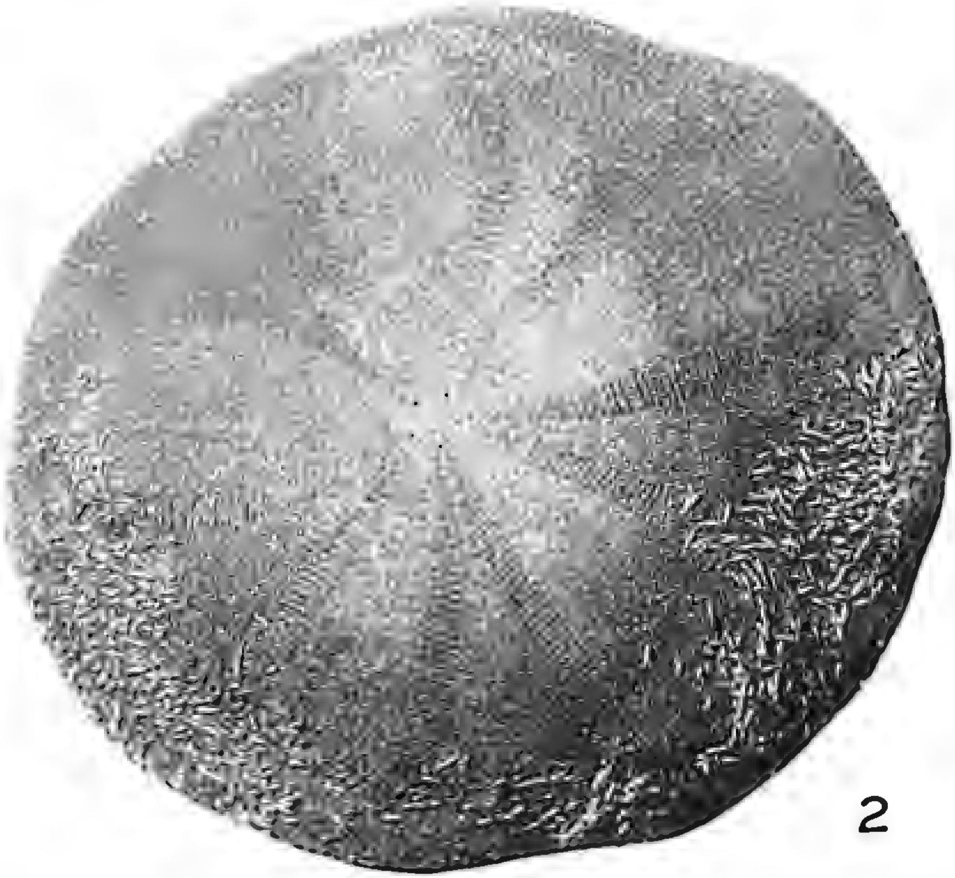

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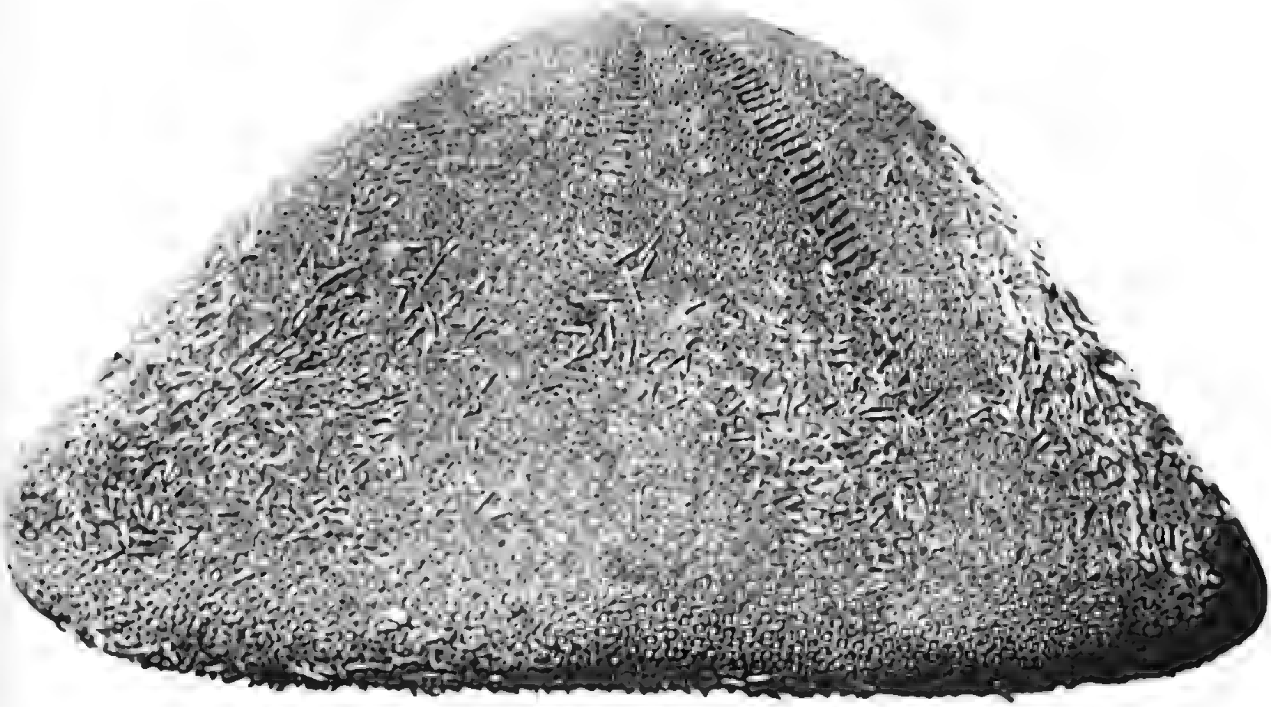

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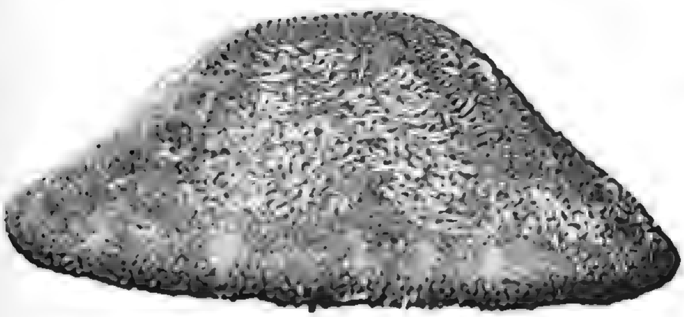

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3

NEW LINGULOID SHELLS FROM LOWER ORDOVICIAN AND MIDDLE PALAEOZOIC ROCKS OF NEW SOUTH WALES

By H. O. FLETCHER

Australian Museum

Plates 31 and 32

Manuscript received, 14-4-61

ABSTRACT

New species of linguloid shells, *Ectenoglossa brunnschweileri*, *Obolus mootwingeensis* and *Lingulella* (*Leptembolon*) *gnaltaensis*, are described and figured from Lower Ordovician (Tremadoc) rocks of the Gnalta Stage in the West Darling District of New South Wales. Recent palaeontological evidence of the age of the Mulga Downs Formation, East Darling District, previously correlated with the Mootwingee Series, is also mentioned. New species of *Lingula* are also described and figured from various Upper Silurian and Devonian localities.

INTRODUCTION

Rocks of the Mootwingee Series are exposed west of the Darling River in the Mootwingee Ranges and contiguous slopes. The term Mootwingee Series was introduced for this group of rocks by Andrews (1922, p. 71) and although recognizing in general appearance a similarity to beds of Devonian age in the eastern portions of the State he was of the opinion they were much older than Devonian and were at least of very early Palaeozoic age.

The Mootwingee Series was subdivided into a lower or Gnalta Stage and an upper or Mootwingee Stage by Kenny (1934, p. 53), who stated that there was no evidence of the specific age of the Mootwingee Series beyond the fact they are post-Torrowangee and pre-Jurassic. It was pointed out by Kenny (1934, p. 53) and by Mulholland (1940, p. 16) that the rocks of the Mulga Downs Formation, which occur east of the Darling River, were lithologically and structurally very similar to those of the Mootwingee Stage. Fossil remains had not been found in either of the sequences but it was accepted by many that they were contemporaneous and were of Upper Devonian age.

The first fossils found in rocks of the Mootwingee Series were a series of linguloid shells which were collected by R. C. Sprigg, Geosurveys of Australia Pty. Ltd., from the upper part of the Gnalta Stage at a locality alongside the old White Cliffs-Mootwingee Road, about eight miles from Mootwingee Homestead. In an unpublished report on this material, R. O. Brunnschweiler in 1957 stated that, although it is not possible to obtain a specific age to the Mootwingee Series on the evidence of the Lingulacea, he considered it reasonable to assume an Upper Devonian or Lower Carboniferous age for the sequence when all the circumstantial evidence was considered.

During a geological reconnaissance of the Mootwingee area in 1957, J. Spence, Frome-Broken Hill Co. Pty. Ltd., collected similar linguloid shells from several localities, including two to three and a half miles between bearings 262° and 287° from Mount Wright Well (Tank 18 on Kenny's map). In 1959, the author accompanied Messrs. R. E. Relph and G. Rose, Geological Survey of New South Wales, to the Mootwingee Ranges and collected linguloid shells from various localities near the old mail road from White Cliffs to Mootwingee, at points from eight to ten miles from Mootwingee Homestead. These localities included that from which R. C. Sprigg collected the original linguloid material. The linguloid shells are very numerous at this locality and occur in a medium of fine-grained yellowish sandstone which outcrops alongside the road. In this bed *Ectenoglossa brunnschweileri* predominates with only occasional shells of *Lingulella* (*Leptembolon*) *gnaltaensis*, while in an overlying bed of a dark coloured coquinite type of rock the shells are mainly those of *Obolus mootwingeensis*.

In September, 1960, Messrs. R. A. Warner and J. Harrison, Delhi Australian Petroleum Ltd., found an outcrop of limestone about two miles south of the Gnalta woolshed. Samples, forwarded to the author, were etched and proved to contain a crowded and comprehensive fauna of perfectly preserved brachiopods and trilobites of definite Middle Cambrian age (Warner, 1961, p. 268).

Following this discovery of the first Cambrian rocks in New South Wales, and because of work being carried out in the area by the Geological Survey of New South Wales, a party including Mr. L. Hall (Geological Survey of New South Wales), Dr. A. A. Öpik (Bureau of Mineral Resources, Canberra), and the author visited the area to carry out field investigations particularly in respect to the fossil fauna.

At this time Messrs. P. S. Lavers and W. H. Jones, of the Geological Survey of New South Wales, had established the following stratigraphic column, which is a modified version of that suggested by A. A. Öpik:—

Upper Cambrian—Lower Ordovician	Sequence IX Mootwingee Series	Shales, sandstones and conglomerates.
Upper Cambrian—Lower Ordovician	Sequence VIII	Shales and siltstone.
Upper Cambrian	Sequence VII	Greywackes, conglomerates calcareous and felspathic sandstone.
Middle Cambrian	Sequence VI	Shales and marls with limestones.
Lower Cambrian—Middle Cambrian	Sequence V	Shale and tuffs with glauconite.
Lower Cambrian	Sequence IV	Acid volcanics, tuffs, shales and cherts.
?	Sequence III	Greywackes, limestones and acid volcanics.
? Upper Proterozoic	Sequence II	Quartzites, red shales, quartz-felspar arenites and conglomerates.
Proterozoic—Archaean	Sequence I	Schists and phyllites.

During the field investigations collections of fossils were made from sequences IV to IX. Archaeocyathids were collected from lenticular limestones near the base of Sequence IV at a locality north-west of Mount Wright. From Sequences V to VIII numerous beautifully preserved trilobites and brachiopods (not linguloids) were collected and the trilobite fauna is now in the course of being described by A. A. Öpik. The Middle Cambrian fauna, including an abundance of *Pagetia*, recorded by Warner (1961, p. 268) occurs in Sequence VI. The linguloid shells from the top of the Gnalta Stage of Kenny, Mootwingee Ranges, have been determined as Lower Ordovician forms and the beds have been referred to Sequence IX. Specimens of *Lingulella* (*Leptembolon*) *gnaltaensis*, rare in the beds at that locality, also occur in rocks outcropping near the woolshed of Gnalta Station (Nucha 1 mile sheet, 1.4 miles at bearing of 295° from Gnalta Well), where they are unassociated with other linguloid species. These beds have been assigned to Sequence IX. This species appears to be congeneric with a linguloid collected at about 12 miles south-west of Alice Springs in beds of the Pacoota Sandstone Formation which is within the limits of late Upper Cambrian and early Lower Ordovician.

In a personal communication I have been informed by Dr. Öpik that in Sequence VIII the lower trilobite horizon is certainly Lower Ordovician (Tremadoc) while the orthoids below could be the top of the Upper Cambrian; in Sequence VII trilobites of the Richardsonellidae have an upper Upper Cambrian aspect by central Australian standards.

The Age of the Mulga Downs Formation

The rocks of the Mulga Downs Formation which occur east of the Darling River have in the past been considered to be contemporaneous with those of the Mootwingee Stage because of a strong lithological and structural similarity. Fossil remains were unknown from the Mulga Downs Formation but it was generally accepted they were of Upper Devonian age.

Several years ago, J. Spence collected well-preserved fish-plates and spines from the Mulga Downs Formation at a locality about six miles from the Wittagoona Homestead. A more comprehensive suite of specimens was later collected from the same locality by E. O. Rayner, Geological Survey of New South Wales, and the author. The fish remains occur in a thin bed of quartz sandstone near the basal beds of the formation and current-bedding, rain-prints and mud-flow casts indicate a shallow water environment.

A second occurrence of fish-remains was located by R. Russell, Cobar Mines Pty. Ltd., at the site of a new tank on Mt. Grenfell Station near its boundary with Tambua Station. A visit to this locality, which, in a direct line, is about 25 miles south of the Wittagoona locality, resulted in a collection of fish-plates very similar to those from Wittagoona and there appears little doubt that both occurrences belong to the same horizon. Further discoveries of fish-plates within the Mulga Downs Formation have recently been made by G. Rose and G. R. Wallis, Geological Survey of New South Wales, and L. Hall, Planet Oil Company.

Following an examination of the fish-plates and spines, Professor E. S. Hills stated that there was no doubt of their Upper Devonian age. I am also indebted to Dr. Thor Ørvig, Swedish Museum of Natural History, for the following information, which was submitted to me after an examination of enlarged photographs of the fish material: "Typical *Phyllolepis* plates are present and other fish remains including

antiarchs and various arthrodires, some of which appear to be new. Two specimens show a circular orbital opening, sensory line canals, and an ornamentation in all probability belonging to a new arthrodire. Another interesting specimen is part of the ventral side of the dermal shoulder girdle of an arthrodire, either belonging to a late representative of the Dolichothoraci (Arctolepida), or to a Coccosteomorph Brachythoracid ". Dr. Ørvig concluded that there can be no doubt at all of an Upper Devonian (Famennian) age for the fish fauna.

In this paper the linguloid shells from the Mootwingee Ranges are described and figured, together with other new species from various localities in New South Wales. *Lingula gregaria* Etheridge is redescribed and refigured. The new species are:—

Ectenoglossa brunnschweileri. Lower Ordovician.
Obolus mootwingeensis. Lower Ordovician.
Lingulella (Leptembolon) gnaltaensis. Lower Ordovician.
Lingula merrimbulensis. Upper Devonian.
Lingula adamsoni. Upper Silurian.
Lingula murrumbidgeensis. Middle Devonian.

Acknowledgments: The author wishes to express his thanks to Professor W. C. Bell, University of Texas, U.S.A., and Dr. G. A. Cooper, United States National Museum, for many helpful suggestions concerning the identification of the Mootwingee linguloids; to Dr. A. A. Öpik, Bureau of Mineral Resources, Canberra, and also to Mr. R. C. Sprigg, Geosurveys of Australia Ltd., for a series of linguloids from the Gnalta Formation and also for permission to use information in an unpublished report on the Gnalta fossils by R. Brunnschweiler.

SYSTEMATIC DESCRIPTIONS

Order **Atremata** Beecher, 1891

Superfamily **Obolacea** Schuchert, 1896

Family **Obolidae** King, 1846

Subfamily **Obolinae** Dall, 1870

Genus **Obolus** Eichwald, 1829

Obolus Mootwingeesis, sp. nov.

(Pl. 31, figs. 1-3, 8; pl. 32, figs. 13, 14)

Holotype F.47427; paratypes F.49056, F.47422. Australian Museum collection.

Description: Shell large, rounded-subtriangular in outline, apical angle about 80°, greatest width slightly anterior to the middle; postero-lateral margins gently curved, almost straight, then broadly curving anteriorly to gradually merge into the slightly curved anterior margin; surface ornamentation consists of fine radiating striae and concentric growth lines with more distant undulations; valves moderately convex posteriorly with fairly steep, rounded lateral slopes in the posterior one-third, convexity gradually but perceptibly flattening towards the anterior margin; umbonal region more acuminate and convexly rounded in the pedicle valve; a fine median ridge extends from the beak to less than half the length of the valve.

Measurements:—

	Holotype	Paratypes	
	F.47427	F.49056	F.47422
Length	29 mm.	32 mm.	26 mm.
Width	22 mm.	29 mm.	21 mm.

Remarks: This species is based on a comparatively large series of both brachial and pedicle valves which vary in size from about 16 mm. to 32 mm. In no instance, however, has it been possible to determine any definite or diagnostic internal features. Several immature specimens indicate that *O. mootwingeensis* is more rounded in outline in younger shells but with growth becomes progressively more acuminate and subtriangular.

In general appearance, like most linguloids, this species is suggestive of several genera but it has been referred to the genus *Obolus* because of its marked resemblance, and apparent agreement in characters, to *O. feistmanteli* (Barrande) from rocks of Lower Ordovician age in Europe. Walcott (1912, p. 391), in a description of this species, mentions the presence of minute terminal vessels which cross the inner surface of the valves near the antero-lateral margins. This pattern of marginal sinuses, figured by Walcott (1912, pl. 12, figs. 9, 9a), is visible on three partly exfoliated specimens of *O. mootwingeensis* (specimens F.48963, F.48974 and F.47424). This feature, pointed out to me by Professor Bell, has not been illustrated elsewhere in regard to species of linguloids.

The presence of fine radiating striae on the inner lamellae, revealed on exfoliated shells, is common to both species but this feature is common in many linguloid shells. Most of the specimens of *O. mootwingeensis* are in various stages of exfoliation and the lamellae appear as imbricating layers which are thickened on the postero-lateral slopes. When completely exfoliated a narrow, well-defined, marginal rim is found to extend along the lateral margins of the valve diminishing in strength towards and around the lateral margins. This is a feature which appears to be similar to that recorded by Walcott (1912, p. 391), and illustrated (1912, pl. 12, figs. 1b and 1e).

No linguloid shells in any way similar to *O. mootwingeensis* have previously been recorded from Australian rocks. It differs from *O. feistmanteli* (Barrande) in its generally larger size, its more acuminate and subtriangular outline and the presence of a posterior median sinus.

Localities and geological horizon: Creek on side of old Mootwingee-White Cliffs Road, via Mount Wright, about eight miles from Mootwingee Homestead; northern side of Mootwingee Range, one mile north of old Mootwingee-White Cliffs Road, about eight miles from Mootwingee Homestead. Upper part of Gnalta Stage, Mootwingee Series, Lower Ordovician.

Subfamily **Linguellinae** Schuchert, 1893.

Lemptembolon Mickwitz, subgenus of **Linguella**

Lingulella (Leptembolon) gnaltaensis sp. nov.

(Pl. 31, figs. 7, 9)

Holotype F.49383; paratype F.49344. Australian Museum collection.

Description: Shell of comparatively small size, slightly longer than wide, pointedly ovate to subtriangular in outline and the greatest width located anterior to the middle; apical angle of the pedicle valve about 100°; lateral margins very

gently curved, almost straight, posteriorly, rather narrowly rounded at the antero-lateral extremities and passing into a gently curved, almost straight, anterior margin; two slightly pronounced roundish edges diverge from the beak to the antero-lateral extremities separating the somewhat flattened surface of the valve from short, steeply sloping lateral and anterior slopes; lateral profile gently convex, beak blunt and rounded; surface sculpture consists of concentric lines of growth with strong undulations anteriorly; exfoliated shells reveal strong and widely separated radial striae with occasional apparent pustules. Details of the interior unknown.

Measurements:—

	Holotype	Paratype
	F.49383	F.49384
Length	16 mm.	18 mm.
Width	15 mm.	17 mm.

Remarks: This species is characterized by its somewhat subtriangular outline, relatively deep and even convexity and short, steeply sloping margins. The figured specimens are brachial valves and are shorter and more rounded at the apex than the pedicle valves.

It has not been possible to determine any definite generic characters of this species but it has a very close resemblance to shells of *Lingulella* (*Leptembolon*) *linguliformis* (Mickwitz) discussed by Walcott (1912, p. 542), from Upper Cambrian and passage beds between the Upper Cambrian and Lower Ordovician of Esthonia. Walcott refers to the characteristic subtriangular outline of the shells, the flat arching, the presence of two roundish edges which converge into the tip of the beak and the lateral and anterior vertical flattening of the borders. These features are also characteristic of *L.* (*Leptembolon*) *gnaltaensis* and it is considered there are close affinities between the two species. The Australian shells are larger in size and generally more truncate anteriorly.

Shells of this species occur in the Gnalta Stage (upper beds), in the Mootwingee Ranges and also in beds of Sequence IX, which outcrop near the Gnalta Station woolshed (Nucha 1 ml. sheet, 1.4 mls. at bearing of 295° from Gnalta Well), where they are unassociated with other linguloid species. The species appears to be congeneric with linguloid shells collected by A. A. Öpik and A. D. M. Bell, Bureau of Mineral Resources, from a locality about 12 miles south-west of Alice Springs, Northern Territory. These shells are abundant in the Pacoota Sandstone, the age of which is within the limits of late Cambrian and late Tremadocian (early lower Ordovician).

Localities and geological horizon: Mootwingee Ranges Creek alongside old Mootwingee-White Cliffs, via Mount Wright, mail road, about eight miles from Mootwingee Homestead; near woolshed of Gnalta Station. Lower Ordovician.

Subfamily **Glossellinae** Cooper, 1956

Genus **Ectenoglossa** Sinclair, 1945

Ectenoglossa brunnschweileri sh. nov.

(Pl. 31, figs. 4-6; pl. 2, fig. 15)

Holotype F.49027, paratypes F.48995, F.49014. Australian Museum collection.

Description: Shell large, elongate, narrowly rectangular, gradually tapering posteriorly to form a sharp and pointed beak in the pedicle valve; brachial valve shorter and rounded at the apex; length more than twice the width with the greatest

width located at about the anterior one-third of the shell; lateral margins gently curved, subparallel, on the anterior half then gradually tapering posteriorly to the apex; anterior margin nearly straight with almost right angle antero-lateral extremities; shell surface smooth, marked by fine concentric lines with occasional ill-defined undulations of growth; inner shell layers marked by distinct and relatively well-separated radiating striae; shell material thin. Valves gently and evenly convex in profile with a slight flattening towards the anterior margin; lateral slopes very slight; a narrow prominent ridge, developed on the interior of each valve, extends along the median line in the anterior half to two-thirds, increasing gradually in width towards the anterior margin.

Measurements:—

	Holotype	Paratypes	
	F.49027	F.48995	F.49014
Length	27 mm.	29 mm.	23 mm.
Width	12 mm.	13 mm.	12 mm.

Remarks: This is a most characteristic species, the shells of which in general appearance look more like the living *Lingula* and *Glottidia* than most fossil linguloids. The genus *Ectenoglossa* (genotype) *Ectenoglossa lesueuri* (Rouault, 1850), was proposed by Sinclair (1945, p. 63) for " shells of elongate linguloid form, thick heavy valves, and with two 'teeth' in the posterior part of the shell ". Three shells of *E. lesueuri*, figured by Davidson (1866, pl. i, figs. 1-3) bear a very close resemblance in general outline with the Australian shells of *E. brunnschweileri*. Hall and Clarke (1892, p. 63) mentioned the presence in internal casts of "*Lingula ? Lesueuri* Rouault" of two deep pits close to the beak, a feature which is present in *E. brunnschweileri*.

In a description of these shells from the Mootwingee Range, R. O. Brunnschweiler (1957, unpublished report), recorded that " the pedicle opening is shared by both valves; it is deeply counter-sunk into the apical part of the umbos and there is a slight thickening of the shell at the anterior end of the pedicle openings ". This feature was suggestive of the genus *Barroisella*, restricted to rocks of Upper Devonian and Lower Carboniferous age, and Brunnschweiler identified the material as *Barroisella* sp. nov. aff. *Lingula squamiformis* Phillips. He recorded the surface ornamentation as follows: " Externally the valves are smooth except for their anterior parts, where strong growth lines from centrically overlapping shell layers become visible. All larger specimens also show a very distinct radial ornament of very fine lines and riblets and of radial wrinkling between the various layers of the shell ".

This species also has a superficial resemblance to *Ectenoglossa nymphoidea* Cooper (1912, pl. 2, figs. 12-20), but differs from that species in being more progressively pointed posteriorly, its smaller size, and in the presence of a median ridge in both valves. It differs from *E. lesueuri* (Roualt) in general outline, the posterior two-thirds of the shell being considerably narrower and pointed.

Locality and geological horizon: Alongside creek on side of old Mootwingee-White Cliffs mail road, via Mount Wright, about eight miles from Mootwingee Homestead. Near top of Gnalta Stage, Mootwingee Series, Lower Ordovician.

SPECIES FROM OTHER LOCALITIES IN NEW SOUTH WALES

Genus **Lingula** Bruguière

Lingula merrimbulensis sp. nov.

(Pl. 32, figs. 9-12)

Holotype F.46149, paratypes F.46150, F.46155; Australian Museum collection.

Description: Shell of medium size, rectangular in outline and about twice as long as wide; sides parallel for the greater length of the shell, bluntly pointed posteriorly, strongly truncated anteriorly; beak small and only slightly projecting; valves moderately convex posteriorly, flatly ridged, wide gently concave sloping lateral slopes, considerably flattened anteriorly. Surface marked by distinct concentric lines with more conspicuous growth lines near the margins.

Measurements:—

	Holotype	Paratypes	
	F.46149	F.46155	F.46150
Length	13.5 mm.	10 mm. (x)	8 mm. (x)
Width	6 mm.	6 mm.	6.5 mm.

(x) incomplete measurement.

Remarks: This species is known by a series of only 10 specimens, mostly incomplete, from the type locality. It is found in a fine ferruginous sandstone in which, apart from a few isolated crinoid stem segments, no other fossils occur. The shell is very thin and fragile and in most specimens the anterior one-third of the valve has broken away. The holotype, a pedicle valve, shows the anterior portion detached but still in position; another incomplete specimen, F.46158 (pl. 32, fig. 9), also has the anterior portion of the valve preserved. It is difficult to determine between ventral and dorsal valves, but it appears that the former has a more defined beak and a greater convexity in the posterior median position.

This species is readily distinguished from other Australian species of Devonian age by its almost rectangular outline, straight anterior margin, and gently arched posterior margin.

Locality and geological horizon: Road cutting, 200 yards north of Bellbird Creek on the Prince's Highway, three miles north of Eden, N.S.W. Lower part of the Merrimbula Formation, Upper Devonian.

Lingula adamsoni sp. nov.

(Pl. 2, figs. 4-7)

Lingula sp. Gill, E., 1940, p. 106.

Holotype F.47400, paratypes F.32965, F.47401; Australian Museum collection.

Description: Shell of medium size, slightly longer than wide, sub-oval in outline; lateral margins sub-parallel narrowly curving anteriorly and passing into an almost straight, gently curved, anterior margin; posteriorly the sides converge to form an obtuse posterior margin; valve profile gently convex with a flattening towards the lateral and anterior margins; surface of shell marked by concentric lines more defined near the margins. Shell material thin.

Measurements:—

	Holotype F.47400
Length	16 mm.
Width	11 mm.

Remarks: This species is represented by a series of about 20 specimens, all of which have been subjected to pressure and are somewhat crushed and distorted. The holotype, except for a slight buckling of the valve, is practically unaltered and has retained its original shape. One specimen, F.31890 (pl. 32, fig. 6), shows a crumpling of the test due to pressure and appears oval in outline, while another valve, F.32965 (pl. 32, fig. 4), shows distortion due to lateral pressure. This species is very common in the sediments at Oak's Creek, near Cootamundra, the type locality, and there seems little doubt that *Lingula* sp., recorded by Gill (1940, p. 106), from Oak's Creek, belongs to this species.

The species is readily recognized by its somewhat ovate outline and relatively wide valves. The species is named after Mr. C. Adamson, Geological Survey of New South Wales.

Locality and geological horizon: Oak's Creek, near Cootamundra, N.S.W. Upper Silurian.

Lingula murrumbidgeensis sp. nov.

(Pl. 32, figs. 1-3)

Holotype F.29897, paratypes F.46150, F.46155. Australian Museum collection.

Description: Shell of medium size, more than twice as long as wide, narrowly elongate oval in outline; lateral margins slightly curved, almost subparallel, with narrowly rounded posterior and somewhat deeply curved anterior margins; pedicle valve deepest at a point about one-third the length from the beak, sloping to the beak and with relatively steep postero-lateral slopes; swelling continues to the anterior margin along the median area but gradually sloping towards the margin and the antero-lateral margins; brachial valve less swollen than the pedicle valve; surface marked by distinct elevated concentric lines somewhat crowded and more prominent on the lateral and postero-lateral regions; median area relatively smooth.

Measurements:—

	Holotype	Paratypes	
	F.29897	F.49393	F.49395
Length	21 mm.	26 mm.	17 mm.
Width	9 mm.	11 mm.	7 mm.

Remarks: This species was recorded by Benson (1922, p. 169) as occurring in Middle Devonian rocks at Goodradigbee and Wolgarlo as *Lingula* sp. indet. The specimens he listed, F.2382 and F.2506, belong to a fairly large series which is recorded in the official registers of the Australian Museum as having been collected from Cave Flat, Murrumbidgee, a locality now covered by water of the Murrumbidgee Irrigation System. It is almost certain that *Lingula* sp., mentioned by Browne (1958, p. 119), is conspecific with *L. murrumbidgeensis*, that author recording it as being not uncommon at many localities in the Murrumbidgee area in a few calcareous bands of the Majurgong beds.

This species is represented by about 40 specimens, all of which have suffered a certain amount of distortion. There is a considerable variation in the size of the specimens and in most cases the shells are complete with both valves.

The elongate-ovate outline of this species, together with the relatively deeply curved anterior margin and the strong convexity of the median area in the posterior half of the shells, distinguishes it from other Devonian species of the genus.

Localities and geological horizon: Cave Flat; beyond woolshed on Bloomfield Station, Murrumbidgee River, N.S.W. Majurgong Stage, Murrumbidgee Series, Middle Devonian.

Lingula gregaria Etheridge

(Pl. 32, fig. 8)

Lingula gregaria Etheridge, R., 1901, p. 120, text fig. 14.

Lingula gregaria Benson, W. N., 1922, p. 169.

Holotype F.7502, Australian Museum collection.

Remarks: Etheridge (1901, p. 119) recorded that " the remains of this *Lingula* are pressed and matted together in enormous numbers, forming a bed of some thickness and extending over a considerable area, so forming an excellent horizon ". He was uncertain, however, whether the geological age of the horizon was Upper Devonian or Lower Carboniferous.

Benson (1922, p. 169) in listing this species recorded its occurrence at Canowindra, Orange and incorrectly at Condobolin. The specimen (F.16513), listed by him as from that locality, is from the type locality at Nyrang Creek. David (1950, p. 249) recorded the zone of *L. gregaria* from Gap Creek, where a layer of impure limestone is composed almost entirely of shells of the species. Sussmilch (1906, pp. 135-136) also recorded the *Lingula* limestone in Gap Creek (portion 276, Parish of Barton), in an unnamed creek on portion 277, and also stated that the species had been obtained from Mount Lambie.

Shells of *L. gregaria* are small, length 7 mm., width 3 mm., elongate subelliptical in outline, with slightly curving almost subparallel sides, gently curving posteriorly to a small projecting beak; antero-lateral margins and anterior margin fairly broadly and similarly curved. Valve surface moderately convex, elevated along a central flattened and triangular area, bounded by two ill-defined ridges which extend from the beak to the extreme antero-lateral margins; shell substance thin and lustrous. Sculpture consists of very fine, almost microscopic striae, which tend to thicken over the marginal parts. At regular and more distant intervals slightly heavy thickenings of the valves mark growth stages.

There is no known species of *Lingula* from Australian rocks with which this species can be compared. Etheridge (1901, p. 119), remarked on its similarity to shells of *L. mytiloides* Sowerby and *L. credneri* Geinitz from the Carboniferous of Britain. This is particularly the case with a specimen of *L. credneri* figured by Davidson (1861, pl. 48, fig. 38) but as usually recognized with linguloid shells most resemblances are entirely superficial.

Localities and geological horizon: Nyrang Creek, five miles from Canowindra (type locality); Gap Creek, Bowan Creek, and Quarry Creek, western flank of Canobolas Mountains, near Orange; Mount Lambie. Upper Devonian.

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EXPLANATION OF PLATE 31

Obolus mootwingeensis sp. nov.

1. Holotype F.47427. Mould of a brachial valve.
2. Paratype F.47422. Mould showing the median internal sinus.
3. A steinkern of the holotype F.47439.

Ectenoglossa brunnschweileri sp. nov.

4. Holotype F.49027. A pedicle valve showing the median sinus.
5. Paratype F.48995. Another pedicle valve.
6. F.49014. A brachial valve.

Lingulella (Leptembolon) gnaltaensis sp. nov.

7. Holotype F.49383. A pedicle valve.

Obolus mootwingeensis sp. nov.

8. F.48974. An immature valve with preserved shell material showing ornamentation.

Lingulella (Leptembolon) gnaltaensis sp. nov.

9. Paratype F.49344. A pedicle valve showing coarse marginal undulations of growth.

EXPLANATION OF PLATE 32

Lingula murrumbidgeensis sp. nov.

1. Holotype F.29897. A pedicle valve.
2. Paratype. F.49395. A slightly crushed pedicle valve of a complete shell showing general outline.
3. Paratype F.49393. An incomplete valve showing surface markings.

Lingula adamsoni sp. nov.

4. Paratype F.32965. A small and crushed pedicle valve.
5. Holotype F.47400. A supposed brachial valve showing only slight distortion.
6. F.31890. Overlapping of the valve surface due to crushing.
7. F.47401. A steinkern of the holotype.

Lingula gregaria Etheridge.

8. Holotype F.7502.

Lingula merrimbulensis sp. nov.

9. F.46158. An incomplete valve showing the anterior portion.
10. Holotype F.46149. A brachial valve showing the anterior portion detached but still in position.
11. Paratype F.46150. A small pedicle valve with the fragile anterior portion missing.
12. Paratype F.46155. A similar specimen to fig. 11.

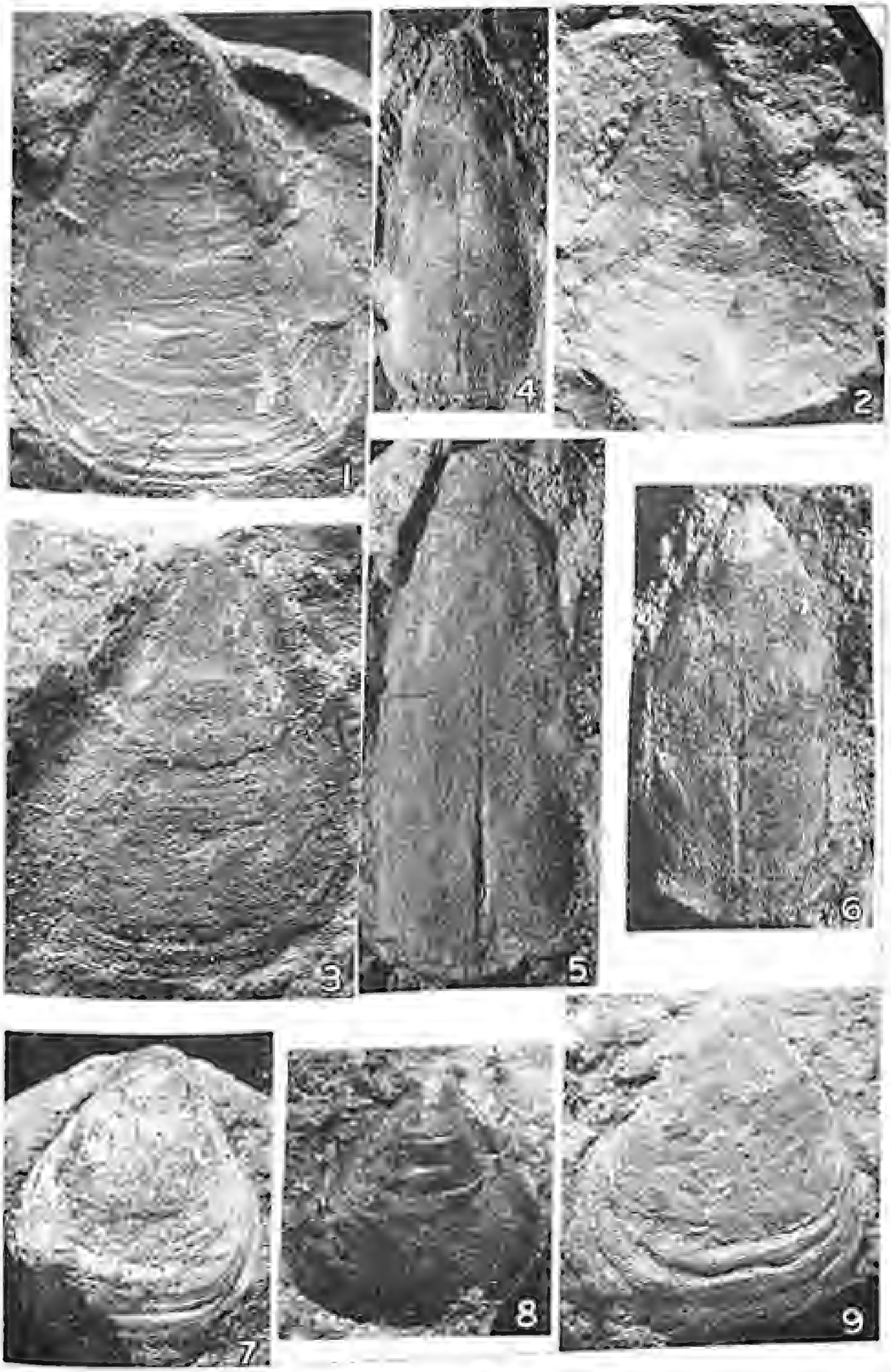
Obolus mootwingeensis sp. nov.

13. F.47428. A pedicle valve showing convexity of umbonal area.
14. F.48963. An incomplete valve, partly exfoliated, showing radial striae on inner laminae.

Ectenoglossa brunnschweileri sp. nov.

15. F.49044. A complete shell showing the brachial valve slightly skewed to reveal the more acuminate pedicle valve.

Sydney: V. C. N. Blight, Government Printer—1964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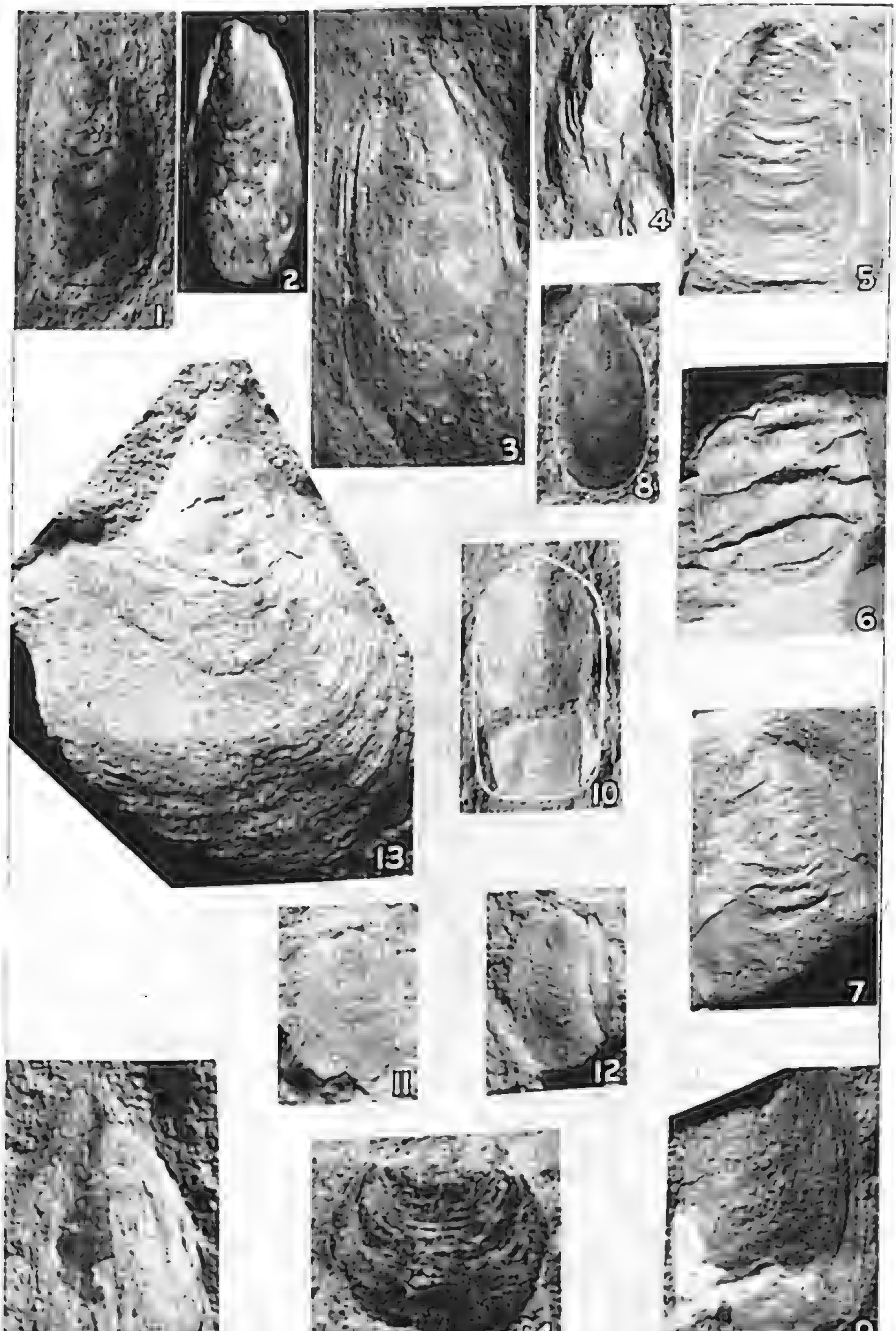
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SEX DETERMINATION OF ABORIGINAL CRANIA FROM COASTAL NEW SOUTH WALES, AUSTRALIA

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Plates 33 and 34 Manuscript received May 1, 1963

INTRODUCTION

Professor N. W. G. Macintosh, Department of Anatomy, University of Sydney, initiated and recommended this project and directed us to the relevant material which has been procured and assembled by him over a period of some 15 years. We acknowledge his assistance and his reading of the final manuscript. Through him we express our sincere thanks and appreciation to Dr. J. W. Evans, Director, Mr. F. D. McCarthy, Ethnologist, and the Trustees of the Australian Museum, Sydney, for the continuing loan of 49 crania; also to Dr. Clarence E. Percy, O.B.E., (formerly) and Dr. John Laing (presently) Director of the Division of Forensic Medicine of the Department of Public Health, N.S.W., through whose collaboration 42 crania of the series here described have become the property of this Department. Their continuing interest in, and consultation on, this material are much appreciated. Three relevant crania in the Macleay Museum, Sydney, were kindly made available by the Curator.

Crania from coastal New South Wales are exceptionally rare. Few if any are known to be located in other State or overseas museums, and there is no publication specifically dealing with a coastal New South Wales series. Some are included, but not specifically identified, in Fenner's 188 skulls from total New South Wales (1939). Twenty male and 12 female coastal crania are identified in Hrdlicka's 1928 catalogue, one was described by Krause in 1897, three are mentioned in Macintosh's (1949) catalogue of Macleay Museum crania and one by Klaatsch (1908). It is curious that in one of the earliest settled regions of Australia there should be greater dearth of Aboriginal skeletal material than in most other regions. An attempt to build up a series of 100 coastal New South Wales crania began in this Department in 1946, and a series of 117 is now available for analysis.

One of us (S.L.), working alone in the 1930s, submitted a manuscript on Australian crania to the late Professor A. N. Burkitt, which was subsequently read and recommended for publication by the late Sir Arthur Keith; it was not published because of lack of funds and intervention of war. This author, in company with Macintosh in 1955 and subsequently alone, revised the original manuscript, making experimental selection of sex characters in Australian crania; by 1962 he had elected 11 traits as significant for sex differentiation. One of us (L.F.) extracted seven from those 11 and the present paper is based on these seven.

With very few exceptions the crania used in this series are recoveries from unmarked burials, the vast majority as a result of chance, and a very few as result of deliberate excavation by Macintosh, McCarthy and Mr. V. Megaw, the latter of the Department of Archaeology, University of Sydney. As far as can be assessed, they are all from adult individuals and they appear to be from full-blooded Australian Aborigines. For a few specimens some post-cranial material is available, but, for the majority, the cranium, often quite extensively damaged, is the sole source of information as to sex. A reliable method of sexing the crania is therefore a prerequisite for any adequate study of the material.

Sexual dimorphism in recent human crania is generally of a low order. Smaller overall size, lighter general construction, weaker muscle markings and certain relative size differences, on average, distinguish female from male crania within a particular group. Further, in various groups features such as glabella or brow ridge development, size of the mastoid process, supramastoid crest or malar tuberosity, and similar features, may have different mean values in the two sexes and be utilized for sexing crania. Borovansky (1936) and Keen (1950) made important studies to assess the value of different characters—both metrical and non-metrical—for sexing crania, and Krogman (1962) has reviewed many aspects of the problem of sexing isolated human crania. In virtually all of the studies hitherto conducted by assessing metrical or/and non-metrical features, about 10-20 per cent. of the crania fall into a category which, on the basis of the particular characters and standards used, includes specimens of both males and females.

More sophisticated statistical techniques are currently being applied to the problem of sexing isolated human crania. Hanihara (1959) used discriminant functions of metrical features to sex Japanese skulls of known sex and his reported sexing error was 10-17 per cent. More recently, Giles and Elliot (1963) described multivariate discriminant functions using various metrical features of the cranium and they were able to sex 82-89 per cent. of American white, Negro and Indian crania. All of the discriminant functions calculated by Giles and Elliot utilize the bizygomatic breadth. Unfortunately, the zygomatic arches are damaged or entirely missing in over 50 per cent. of the crania in the present series and, in a number of the remaining crania, other measurements, particularly those involving the prosthion, are not possible because of damage. Nevertheless, it was felt worth-while to try their function No. 3 (which utilizes eight metrical features) on the New South Wales crania.

Using the Giles and Elliot function No. 3 and sectioning point to sex a small series of the New South Wales crania, many crania which seem clearly male on subjective non-metrical assessment (in two cases backed by post-cranial characters) were sexed as female. Also, one cranium clearly female on morphological and post-cranial features was indicated as male. For these reasons, and because there were insufficient crania of " known " sex at this stage to make a new sectioning point, it was decided to attempt another approach to the problem of sexing the New South Wales Aboriginal crania. In any case, because of the damage mentioned above, less than 50 per cent. of the crania could be subjected to the test.

A more subjective method to be described below was thus evolved which, for the present purposes, has given what appears to be most satisfactory results. However, subjectively, sexual dimorphism seems to be at least as great in Australian Aboriginal crania as in the groups for which Giles and Elliot devised their technique and, what is more, their functions even gave good results with chimpanzees. The Giles-Elliot discriminant functions are simple, practical and completely objective. Thus, when metrical data for the two sexes were calculated on the basis of the sexing method described below, a new sectioning point for their function No. 3 was computed. The results (described below) were now most encouraging.

METHODS AND MATERIALS

In considering which features to use for sexing, it was decided to concentrate mainly on morphological (descriptive), non-metrical characters at this stage, as the significant sex differences in these features are fairly well established. However, in two cases (palate size and mastoid size) the characters were objectively assessed by metrical means. On the basis of the sexing studies mentioned above, and taking cognizance of the special features noted on the New South Wales Aboriginal crania,

11 characters were chosen for trials in sex determination. For each of these characters three classes were delineated to include the different amounts of development of the feature. Class 1 in each case includes the most characteristic female form of the feature, class 3 the most male form and class 2 the intermediate group. To facilitate classification of the crania, unless metrical or similar standards were used, two crania were selected from the New South Wales group to mark the limits of class 2. Each feature was then studied separately in the complete group of New South Wales crania and the 11 values thus obtained for each cranium were totalled. Table 1 lists the 11 characters used, some relevant remarks and the reference numbers of the two crania (or values of the other standard) utilized for assessing the three classes of the particular character.

Of the 117 New South Wales coastal Aboriginal crania assembled for study, the sex of only one (a dissection room male cadaver) is known from records and only another 18 (nine males and nine females) have sufficient associated post-cranial bones for their " cranial sex " to be confirmed by post-cranial features (mainly of the pelvis and femur). As 19 crania are clearly an inadequate sample for developing a sexing technique, it was decided to examine first all of the crania in which all of the 11 sexing features decided upon were present.

RESULTS

List 1 shows the distribution of 107 Aboriginal crania using the 11 characters listed in Table 1. If one notes the distribution of the crania of known sex, there is a fair suggestion of bimodality for the distribution. The left-hand group (including all of the known females) covers a range of 11-17 and the specimens form a clear, leptokurtic distribution. The right-hand group (including all of the known males) covers a range of 19-32. These latter specimens do not form as smooth and definite a curve as the left-hand group and, in addition, their distribution is probably platykurtic. The differences in shape of the distributions of the two groups may merely reflect peculiarities of the three arbitrary categories chosen for each character, or, on the other hand, they may be evidence of greater variability in the group including the known males. In view of the known male and female crania falling on either side of category 18, it would seem quite likely that this technique separates at least the majority of male and female crania into two distinct groups.

In an effort to improve the technique, it was next decided to attempt to assess which of the 11 characters utilized were the most useful for determining the sex of Aboriginal crania. In order to do this, it was necessary to accept some preliminary assessment of probable male and female crania—the specimens of known sex alone, as pointed out above, being too few in number. The distribution of the cranial values in List 1 suggested that, by removing the crania in the region of possible overlap, the sexes of at least most of the remaining crania would be unequivocal. After further consideration of List 1, it was decided to eliminate categories 17-21. The asymmetry of this selection of categories around the meeting point of the two groups (category 18) was deemed advisable because of the leptokurtic nature of the distribution of the " females " and the apparently platykurtic distribution of the " males ". The 54 " male " and 36 " female " crania so indicated were then carefully studied subjectively and in none was there any strong indication of disagreement with the sex indicated. The mean values for each of the 11 characters were then calculated separately for " males " and " females " of the group and the differences between these values for each character in the two sexes recorded. Table 2 shows the results of this examination. On the standards used for delimiting the classes, the features yielding the greatest differences between the sexes (as separated by the above technique) can be readily seen.

TABLE 1

Characters Used for Sexing Australian Aboriginal Crania from Coastal N.S.W.

Character	Remarks	Class 2 limits
Glabella	Prominence was assessed according to Martin's modification of Broca's scale (Martin, 1928).	Grade IV (Martin).
Supercilliary ridges (Plate 33).	These were graded according to their prominence. Their presence is judged independently of the size of the glabella and zygomatic trigone (see Note 1 below).	>B. 171B <5
Zygomatic trigone (Plate 33).	The development of this feature (also known as the trigonum supraorbitale or external angular process) is similarly independent and should be assessed without reference to the above two.	= or >473 <N.P.
Forehead contour ..	The relative degree of recession was noted independently of glabella development. More vertical, class 1; more horizontal, class 3.	>S. 1748 = or <123
Temporal crests	The relative degree of prominence was estimated, mainly as seen on the frontal (crista frontalis lateralis).	>8 <S. 1609
Malar size	Size was judged in terms of external surface area of malar.	>175 = or <76
Malar tuberosity (Plate 34).	Prominence of the tuberosity, which, as noted by Fenner (1939), may take the form of a ridge in the Australian Aboriginal.	>123 = or <S. 744
Supramastoid crest ..	The degree of development was noted because of sex incidence observations by Keen (1950).	>S. 744 = or <N.P.
Mastoid process	Length x width x depth (nrst. mm.) ÷ 100. (See note 2 below).	55-80
Occipital markings (Plate 34).	General ruggedness, depth of fossae for rectus capitis posterior minor and semispinalis capitis mm., ruggedness of inion region, development of occipital crest and torus.	= or >512 = or <123
Size of palate	Maximum alveolar length x breadth (nrst. mm.) = 100.	35-39

Notes :—

1. The supraorbital region has been treated in this study as consisting of three distinct entities (Martin, 1928), glabella, supercilliary ridges and zygomatic trigones. In the Australian Aboriginal these three features show a considerable degree of independent variation. The development of the supraorbital region as a whole contributes strongly to the male or female appearance of the cranium.

2. The following are the definitions of the mastoid process measurements : Length : From the Frankfurt Horizontal Plane, vertically downward to the level of the tip of the mastoid process. Width : Maximum measurement in the sagittal plane and parallel to the Frankfurt Horizontal Plane, from the uppermost point on the anterior margin (in practice, the lowest point at which the tympanic plate abuts against the mastoid process) to the level of the most posterior point on the posterior surface. Depth : Maximum measurement in a coronal plane and parallel to the Frankfurt Horizontal Plane, from the uppermost part of the digastric fossa medially, to the most lateral point on the mastoid process.

3. Plates 33 and 34 illustrate class 2 limits of the morphological features utilized in the final seven character sexing technique. For the glabella, Martin's modification of Broca's scale was used; the palate and mastoid process were assessed by metrical means.

LIST 1

Distribution of 107 Australian Aboriginal Crania from Coastal N.S.W., Using 11 Sexing Characters

Values for sum of 11 Characters																					
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
..	..	B169A†	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	512†	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	506	..	..	..	..	..	..	..	..	..	496	..	..	..	..	..	..	..	..	..
..	240†	S2256	YB†	..	..	..	..	..	..	..	..	S1614	..	1*	..	..	..	493*	..	..	..
..	510	S2093	S1748	463	..	..	..	..	..	..	S1755	372	..	504*	505*	..	..	S2218	..	..	..
..	S1825	S1734	S1616	509	..	..	..	B171B*	..	..	306	371	..	503*	B160	NP*	274*	S1828	..	..	..
..	352	S2079	S1612	S1615	S1613	..	..	S637	..	B169B*	1210	275	S774	S1749	1204	12	S267	1169	..	..	..
..	A17590	E17551	1181	S1157	B163A	473†	..	S2105	1196	B164*	S1989	179	E12778	177	264	180	S2104	S1611	S1609	..	..
511†	E8664	11	S1921	S1643	B165	B135†	489	507	S595	9	465	123	497	6	30	239	490	S1916	1180	S394	..
381†	175	8	378	173	7	1201	460	1185	450	1238	M62	10	M60	502	5	508	M64	307	340	76	377

† = Known ♀

* = Known ♂

TABLE 2

Examination of 11 Characters in 90 Australian Aboriginal Crania from N.S.W. for their Value in Sexing Determinations

	Glabella	Super-cilliary ridges	Zygomatic trigone	Forehead contour	Temporal crest	Malar size	Malar tuberosity	Supra-mastoid crest	Mastoid process	Occipital muscle markings	Palate size
Male mean ..	2.26	2.41	2.57	2.22	2.30	2.35	2.35	1.61	2.28	2.55	2.69
Female mean	1.08	1.03	1.31	1.25	1.36	1.61	1.00	1.29	1.03	1.05	1.55
Difference ..	1.18	1.38	1.26	0.97	0.94	0.74	1.35	0.32	1.25	1.50	1.14

Varying numbers of characters were then omitted on the basis of the results shown in Table 2 and the values for each of the 107 crania were plotted on separate diagrams for each new combination. After a number of different trials, it became evident that the elimination of the four characters giving the smallest differences in mean values between males and females (supramastoid crest, malar size, temporal crest and forehead contour) gave the most satisfactory division (List 2). Fewer than seven characters resulted in too few categories and consequently one or more categories included specimens of both sexes. When more than seven characters were used, some crania in the " male " or/and " female " groups, on subjective assessment, strongly suggested that they ought to be grouped with the opposite sex to which the technique had assigned them. With the seven best characters indicated in Table 2, there were no obvious disagreements and the few " subjectively doubtful " crania were clearly assigned to one or other sex.

The shapes of the distributions of the individual crania in the male and female groups, as determined by these seven characters, show some differences to the distributions found using all 11 characters. The female (left-hand) group now appears to form either the right half only of a leptokurtic curve with a mean value at about category 7, or a much less leptokurtic curve, with the mean value at about category 9 and the left half of the left limb of the distribution compressed into category 7. The male (right-hand) group falls into a considerably more regular and less platykurtic shape than when the 11 characters were used. These differences between the male and female distributions (when seven instead of 11 characters are used) may partly be ascribed to the reduced number of categories when fewer characters are included. The apparent compression of part or all of the " left limb " of the female distribution suggests that, in some or all of the characters utilized, class 1 at least should be subdivided into two or more categories. The condensation of all of the female crania into only five of the 15 possible categories could be a chance result of the particular limits chosen for the three classes of some or all of the characters, but may well be due to the smaller range of variation characteristic of the morphological features of human female crania when compared to those of males (e.g., Klaatsch, 1908).

The only real shortcoming of the sexing method using the above combination of seven characters was the fact that there is no cranium of known sex in category 11, although, subjectively assessed, all of these crania appear to be from females. In an attempt to resolve this point, and also to test the method generally, all of the Australian Aboriginal crania of known sex that could be obtained from any part of Australia were processed and plotted, using the same seven characters. The results of this test are shown in List 3. In this group of crania, all of the specimens are correctly sexed and, further, a female cranium falls into category 11, confirming that this category belongs to the female group and that the 11/12 boundary is the sectioning point for crania of the two sexes.

DISCUSSION

Various groupings of characters were tried. In a total of 14 different combinations using 5 to 11 features, no cranium indicated as male by the final technique, or strongly suggesting male characters subjectively, fell into or below a category including a known female. Six crania, which by the final sexing were designated as female, fell into or above a category containing a known male in one or more of the other combinations tried. [This is similar to the findings of Hrdlicka (1928, Pg. 2) who noted that " sexing of the Aboriginal skull is not always easy, some of the females closely resembling males ".] Of these six female crania, cranium

LIST 2

Distribution of 107 Australian Aboriginal Crania from Coastal N.S.W., Using Seven Characters

Values for Sum of Seven Characters														
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
511†	..	..	..	..	..	..	..	..	..	..	..	..	..	..
381†	..	..	..	..	..	..	..	..	..	..	..	..	..	..
240†	..	..	..	..	..	..	..	..	..	..	..	..	..	..
S1612	..	512†	..	..	..	..	..	..	..	..	..	..	..	..
510	..	YB†	..	..	..	..	..	..	B164*	..	..	..	..	..
S1825	..	S1748†	..	..	..	..	..	..	1*	..	..	..	..	..
1181	..	509	..	..	..	..	..	..	496	NP*	..	..	..	..
S2256	B169A†	1185	..	..	..	..	..	..	S1614	274*	S1611	493*	..	..
352	506	S1616	..	..	..	..	..	..	S744	505*	S267	1169	S394	..
S2093	S1613	1201	473†	..	..	..	B169B*	..	372	504*	B160	S1609	12	..
A17590	S1157	B163A	B135†	..	..	..	S1749	..	S2218	503*	E12778	S2104	S1916	..
E8664	463	S1921	S1615	507	B171B*	S637	179	S1755	1210	1204	177	490	1180	..
S2079	S1734	S1643	B165	1238	1196	306	465	371	275	6	239	S1828	340	..
E17551	173	460	7	489	S2105	S595	123	497	M60	5	264	307	76	..
175	11	8	378	450	M62	S1989	9	10	502	508	30	180	M64	377

† = Known ♀.

* = Known ♂.

LIST 3

Distribution of 35 Australian Aboriginal Crania of Known Sex, Using Seven Sexing Characters (Females—large italicized numbers)

Values for Sum of Seven Characters														
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	505*	. .	. .	. .	. .
. .	. .	_512*_	. .	. .	. .	. .	. .	. .	. .	504*	. .	. .	. .	. .
_511*_	_B169A*_	_S1748*_	. .	. .	. .	. .	. .	. .	. .	503*	. .	. .	. .	. .
_240*_	_SL11_	_YB*_	_B135*_	. .	. .	. .	B169B*	. .	. .	NP*	. .	. .	. .	. .
_381*_	_B170_	_475_	_473*_	_B142A_	. .	. .	B164*	SL15	. .	274*	. .	75	. .	. .
_499_	_SK63_	_333_	_SL14_	_332_	B171B*	320	248	330	1*	334	. .	493	SK72	. .

* = N.S.W. crania.

1238 is the one which most commonly changes to the male side and 489 only changes when less than seven characters are used. The development of certain features should be noted in these six crania: numbers 1185, 450 and 507 have well developed supramastoid and temporal crests, in numbers 1238 and 489 the supramastoid crest is well developed and in cranium number 7 the forehead contour slopes backwards markedly as in males. It is on these features that the balance is tipped towards the male side in certain of the combinations tried. As these three features were shown in Table 2 to be the least reliable of the characters tested for sexing, it seems likely that the designation of these crania as female is correct.

For most of the characters studied, male and female crania were found which showed development typical, or occasionally even extreme, for the opposite sex. The percentile frequencies for each class of each character in males and females separately are shown in Table 3. Certain crania (e.g., 9, B. 171B, 1185 and 1238) presented particular difficulties for subjective sexing as "base" and "brow" indicated opposite sexes. The relative weight given to these two regions may swing the balance one way or the other in such a case. In the sexing system described above, the "brow region" is considered in three characters (glabella, supercilliary ridges and zygomatic trigone) and the "base" in two (occipital markings and mastoid process). This may well lay too much stress on the brow ridges, particularly in view of the fact that the occipital markings were shown in Table 2 to represent the best single item for discriminating between the sexes.

With regard to the probable degree of accuracy of the technique finally settled on, it is of interest to note that the six specimens discussed above constitute less than 6 per cent. of the total series. Another approach to the accuracy of the test would be to consider the crania in the categories on either side of the sectioning point as doubtful (four in category 11 and four in category 12). This would leave 92·5 per cent. as accurately sexed but, as the sex of one of the crania (B. 171B) is confirmed by the pelvis, the figure would rise to 93·5 per cent. On either hypothesis at least 90-95 per cent. would seem to be the likely degree of accuracy of sexing obtained.

Hrdlicka (1928) sexed 24 of the crania used in this study and 22 (91.7 per cent.) are in agreement. S. 1614, which Hrdlicka called a female, falls into category 16 and, except for slightly small overall size, appears clearly male on morphological characters. S. 1643, which Hrdlicka makes a male, falls into category 9 and seems clearly female, although it is possibly slightly larger than an average female. Stewart (1954) has summarized previous work in which some of Hrdlicka's subjective sexing was called into doubt. He points out that Hrdlicka tended to be biased by overall size and would on occasions change his subjective morphological assessment after completing his measurements.

The difficulties with utilizing the discriminant functions of Giles and Elliot (1963) for sexing the New South Wales crania were outlined above. Using the sexes established in the present study, mean values were calculated for males and females of the series (Freedman, 1964) and, from these, a new sectioning point, 6216.32, was calculated for their No. 3 function. Their No. 3 function is : 6.083 glabella-occipital length — 1.000 maximum width + 9.500 basion-bregma height + 28·250 maximum diameter, bizygomatic + 2·250 basion-prosthion + 9·917 prosthion-nasion height — 19.167 palate, external breadth + 25.417 mastoid length. With the new sectioning point calculated, this function "correctly" assessed 86.7 per cent. of 45 Aboriginal crania (mainly from New South Wales). Of the six crania in which the two techniques (i.e., the one by Giles and Elliot and that by the present authors) disagreed, the Giles-Elliot function made S. 673, S. 1614, 5, M. 62 and B. 169B female, and 473 male. The first four crania all have small bizygomatic breadths and the fourth one, in addition, has a small mastoid process. The fifth, B. 169B, has a particularly short mastoid process. These features receive great weight in the Giles-

TABLE 3

Frequencies of Classes 1-3 for 11 Characters in 107 Australian Aboriginal Crania from N.S.W. (in percentages)

Class	Glabella		Super-cilliary ridges		Zygomatic trigone		Forehead contour		Temporal crest		Malar size		Malar tuberosity		Supra-mastoid crest		Mastoid process		Occipital muscle markings		Palate size	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	23.0	88.2	15.4	90.4	10.9	71.2	18.5	74.5	13.8	59.6	4.7	33.3	21.9	97.9	32.3	62.0	15.4	92.0	6.1	90.2	1.6	50.0
2	32.3	11.8	40.0	7.7	26.6	25.0	52.3	21.6	53.9	36.5	65.6	54.2	31.2	2.1	41.5	28.0	52.3	8.0	37.9	5.9	34.9	38.5
3	44.7	0.0	44.6	1.9	62.5	3.8	29.2	3.9	32.3	3.9	29.7	12.5	46.9	0.0	26.2	10.0	32.3	0.0	56.0	3.9	63.5	11.5

Elliot functions. The sixth cranium (473) is clearly female on morphological cranial and post-cranial features, but its cranial dimensions generally are rather large for a female. It is of interest that none of these six crania are amongst those discussed above whose sex was "affected" by changes in the number and particular morphological characters used to assess sex.

A final interesting piece of circumstantial evidence about the accuracy of the sexing technique described above, comes from the Aboriginal practice of evulsing one or both of the upper medial incisors in males. Tench (1793) described the method of evulsion of these teeth in men and noted that, although the ceremony was not universal, it was "nearly so", and mentioned exceptions. The tooth was first loosened by the gum being scarified on both sides with a sharp shell. One end of a stick was then applied to the tooth and the other end struck gently several times with a stone until the tooth became freely movable. The *coup de grace* was then given with a smart stroke. Many of the crania in this study come from a later period than that referred to by Tench and the custom may well have been dying out, but it was nevertheless felt to be of interest to examine the series for this feature. An upper medial incisor has been evulsed in 44.4 per cent. of the male crania and 4.8 per cent. of the female crania. Of the 30 crania where an upper medial incisor had been evulsed, 28 (93.3 per cent.) were diagnosed males. The two female crania were unambiguously female; their incisor loss may have been accidental or a variation in what is more customarily a male prerogative of ritual.

CONCLUSIONS

The sexing technique described in this paper is considered as having been devised as a tool for a specific purpose, namely, the division of a collection of New South Wales coastal Australian Aboriginal crania into two sexes for metrical and non-metrical study. This it would seem to do with at least 90-95 per cent. accuracy. Where one or even two features are not present, as in the 10 crania originally eliminated, substitution of mean values and, when in doubt, maxima of first one and then the other sex, made sexing of most of even such crania feasible. On the limited sample tried, it seems possible that the technique will also work on Aboriginal crania from other parts of Australia. As particular crania or similar rigid standards were used to classify each character, and the characters used for discrimination were chosen objectively on mean differences, it is felt that the technique finally arrived at closely approaches objectivity.

With the calculation of a new sectioning point, the Giles-Elliot No. 3 discriminant function appears to be a most useful technique for sexing Australian Aboriginal crania, provided damage, especially to the zygomatic arches, is not extensive. A discriminant function calculated on the basis of the metrical features of the New South Wales crania themselves, may, however, be the ultimate answer.

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EXPLANATION OF PLATES

Plate 33.—Crania showing the limits of class 2 of the morphological features used for sexing Australian Aboriginal crania from coastal N.S.W. *Above:* antero-inferior aspect of supercilliary ridges; smallest on left (B. 171B), largest on right (5). *Below:* antero-medial aspect of zygomatic trigone; smallest on left (473), largest on right (N.P.).

Plate 34.—Crania showing the limits of class 2 of the morphological features used for sexing Australian Aboriginal crania from coastal N.S.W. *Above:* postero-lateral view of malar tuberosities; smallest on left (123), largest on right (S. 744). *Below:* basal view of occipital muscle markings; least marked on left (512), most marked on right (123).

Sydney: V. C. N. Blight, Government Printer—1964

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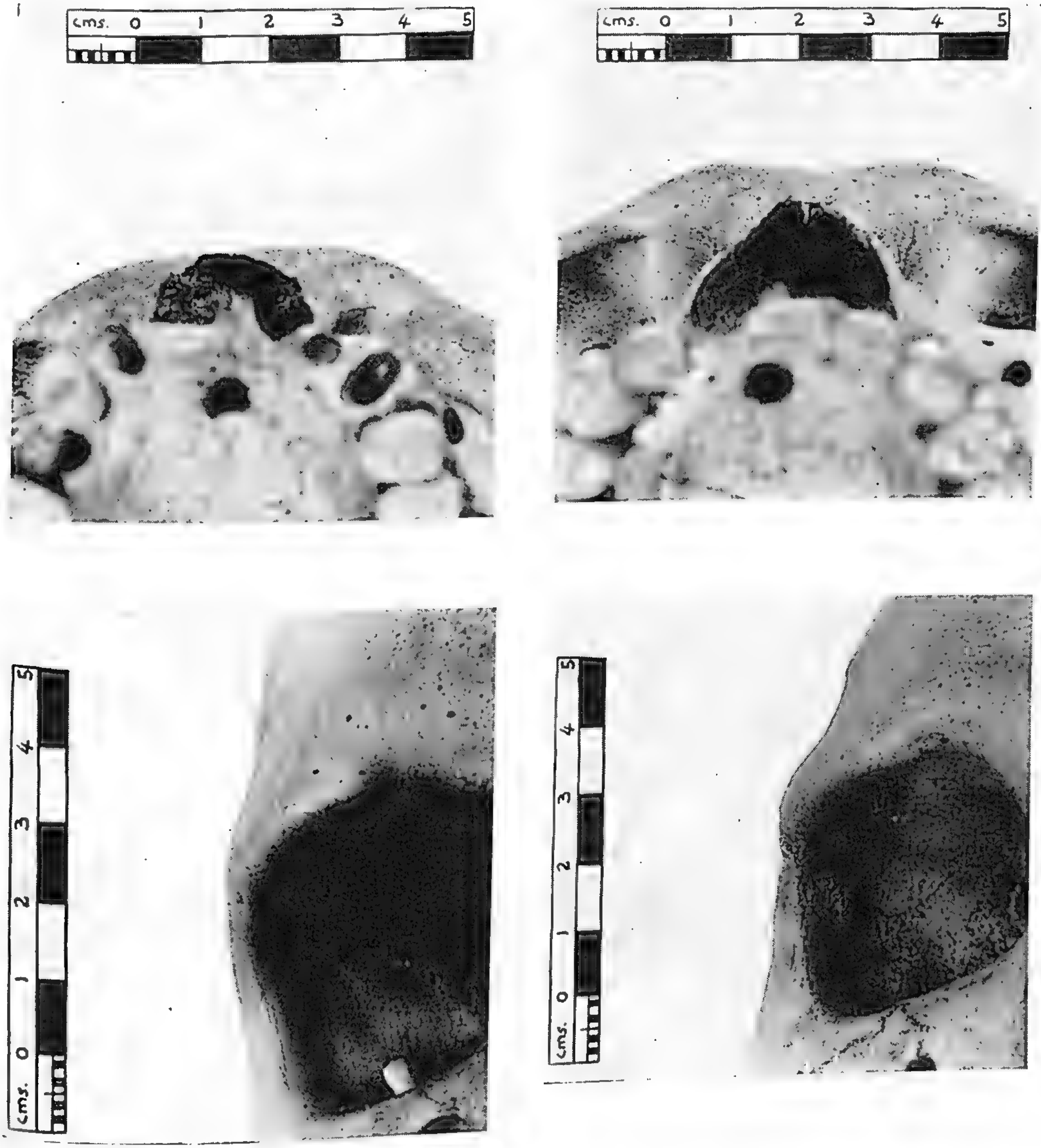

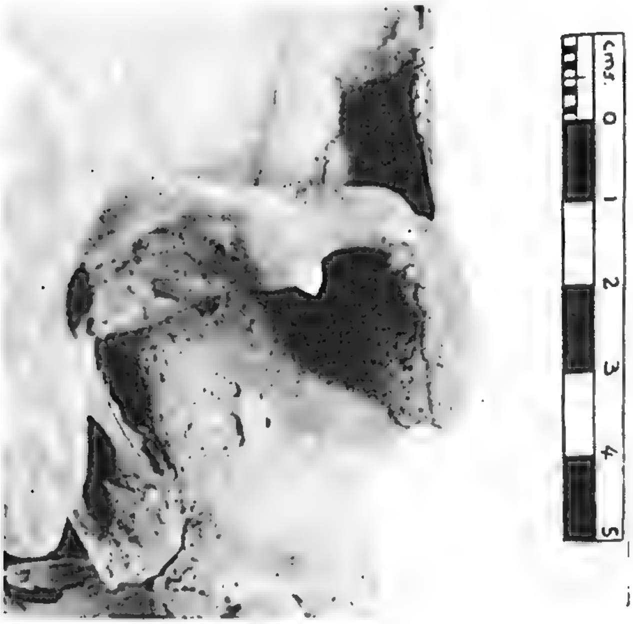

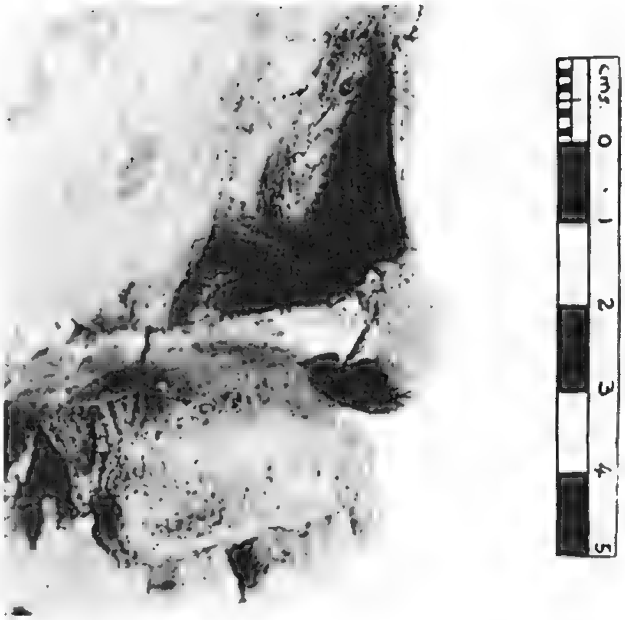

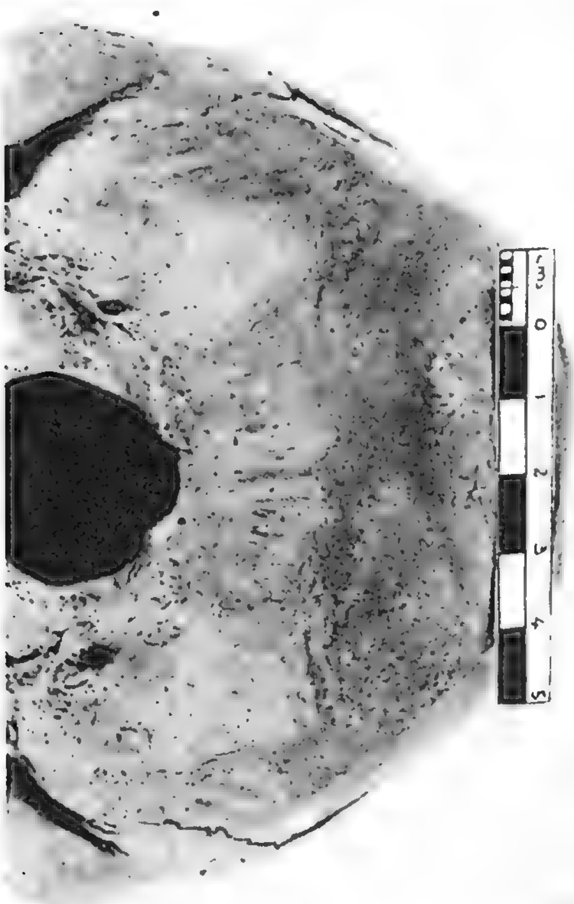

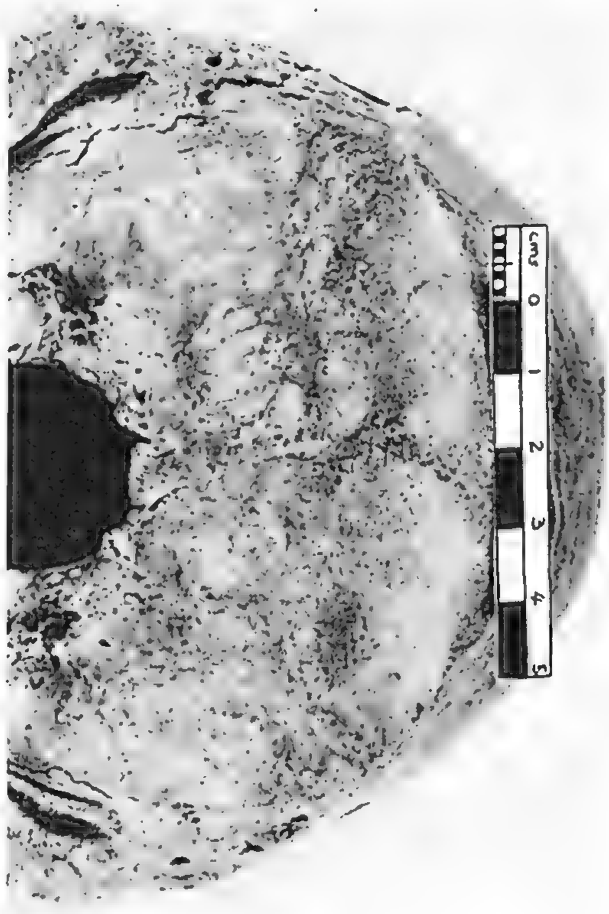

METRICAL FEATURES OF ABORIGINAL CRANIA FROM COASTAL NEW SOUTH WALES, AUSTRALIA

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Figures 1-5 Manuscript received May, 1963

INTRODUCTION

The racial origin of the Australian Aboriginal is still the subject of much controversy, despite the considerable number of studies which have been made over the last 100 years. Past investigations have included many aspects of physical anthropology, archaeology, linguistics and social anthropology, but different approaches, techniques and interpretations have resulted primarily in two basically opposed hypotheses. These are: (*a*) The Aboriginal Australians are the descendants of a single basic stock which invaded the virgin continent. Local differences found to-day in the frequencies of some of their physical features are primarily the result of chance variations which became established in semi-isolated populations (cf. Abbie, 1951). (*b*) Successive waves of immigrants of different basic stock colonized the Australian continent. The frequency variations of certain features found between Aborigines inhabiting the different parts of the Australian continent are closely related to the varying proportions of the contributing stocks in these populations (cf. Birdsell, 1949 and 1950).

The current study deals with the variations in certain metrical features of Aboriginal crania from various parts of coastal New South Wales. With this as a basis, it is hoped to record, analyse and compare cranial data from Aboriginal populations of various other localised areas of Australia in an attempt to test, and possibly help resolve, the differences between the two currently held divergent views.

MATERIALS

The material studied includes the crania of 65 males and 44 females recovered from various parts of coastal New South Wales, Australia. This area includes a strip up to 40 miles wide along the entire length of the coast of that State. The specimens thus all come from a region east of the Great Dividing Range. Figs. 1 and 2 show the localities from which the specimens come and it can be seen that, with very few exceptions, the crania actually come from places on or very close to the shore line.

The specimens used are all considered to come from fully adult individuals. In all of the crania the basioccipital-basisphenoid suture is synostosed. In addition, both M3 teeth are fully erupted in both jaws or, where one or more is absent in either jaw or on either side, the attrition of the other teeth and the amount of suture closure generally indicated the congenital absence (or very considerably delayed eruption) of these teeth.

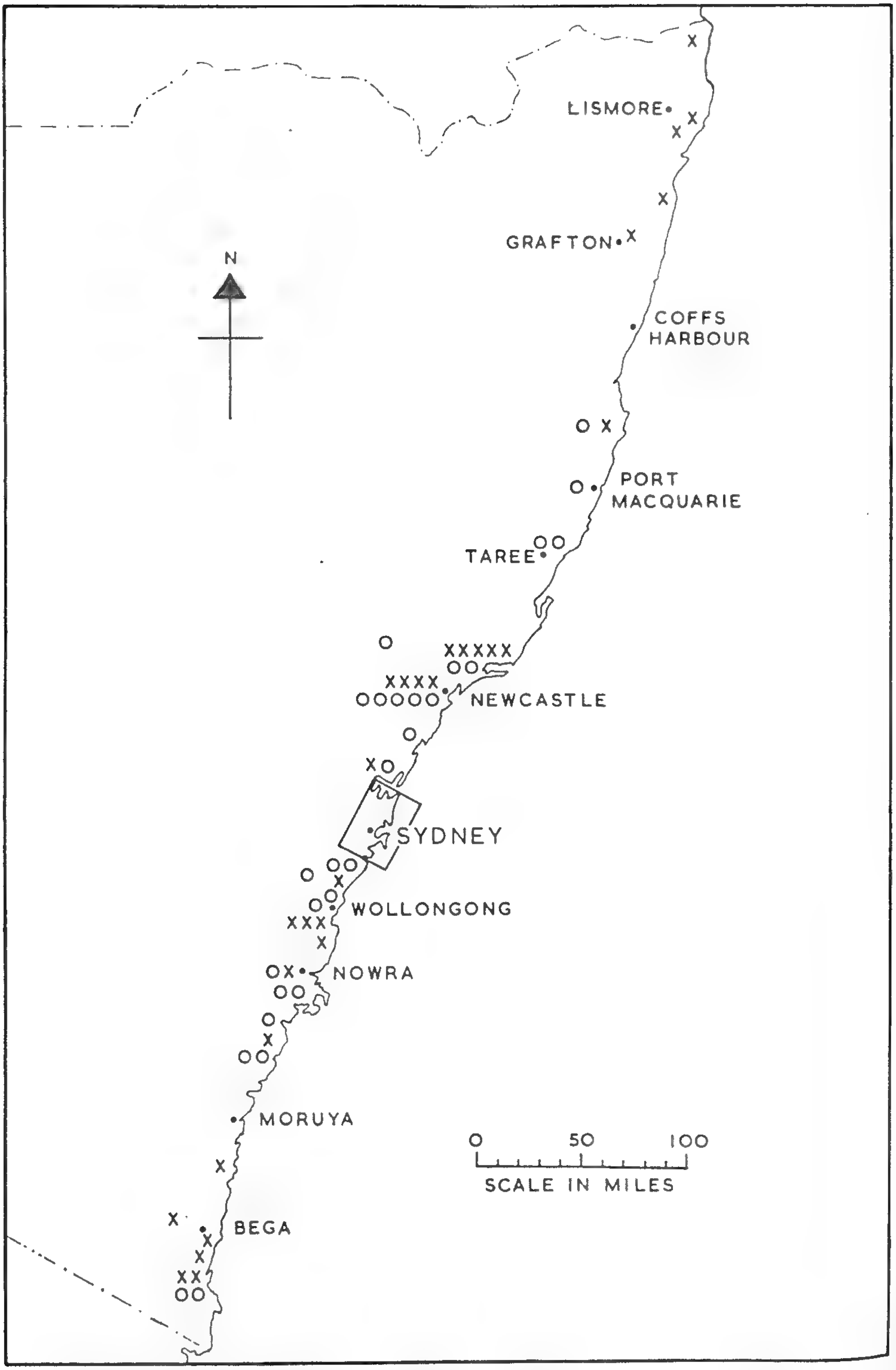

Figure 1.—Map of coastal New South Wales, Australia, showing the localities of the specimens used in the northern and southern groups. X = males; O = females.

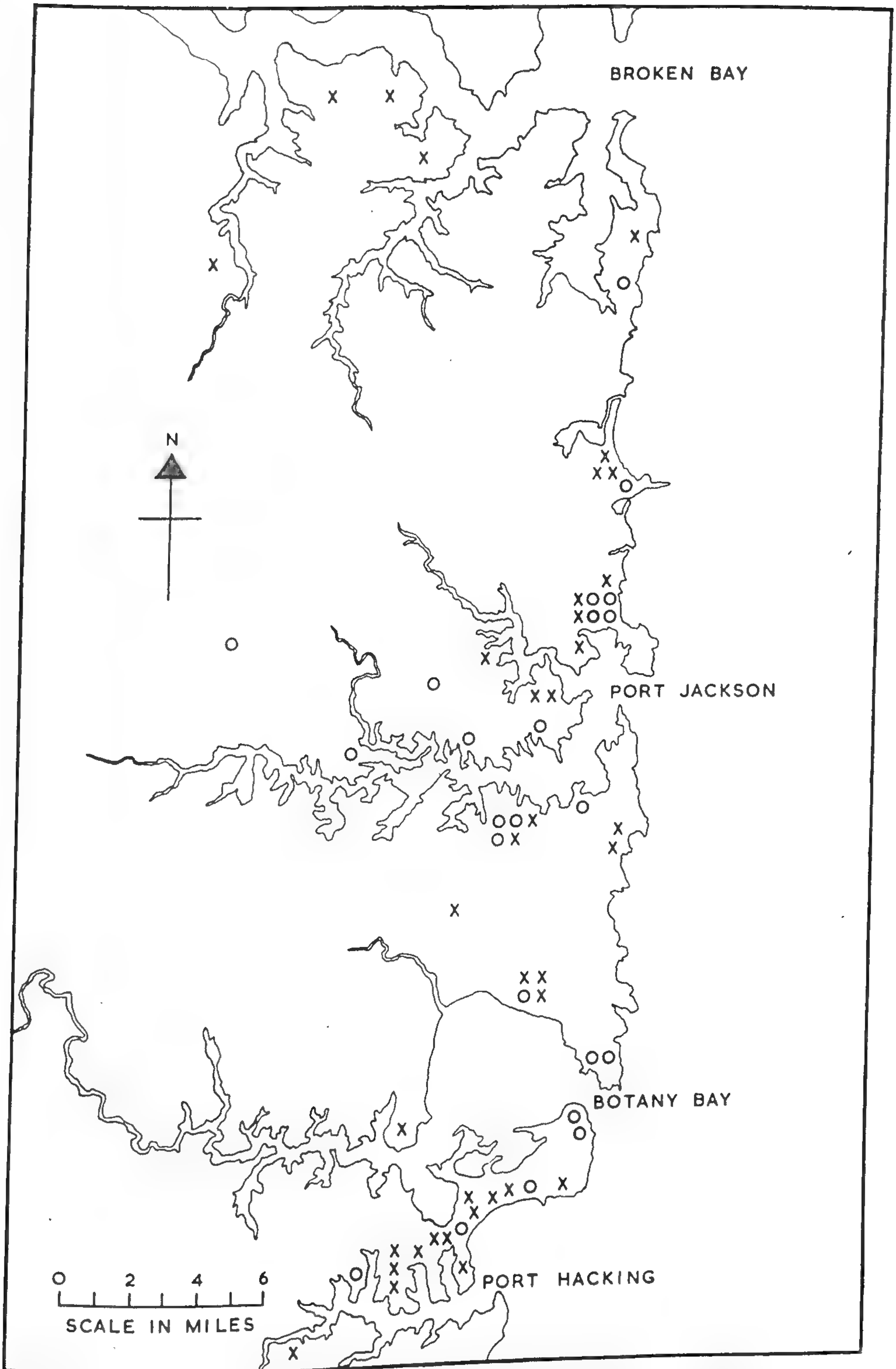

Figure 2.—Map of Sydney area (central group) showing the localities of the specimens used. X = male; O = female.

Sexing was done by assessing a combination of metrical and non-metrical features. Details of the technique and results have been described elsewhere (Larnach and Freedman, 1964). Despite the fact that the sexes of very few of the crania are definitely known from records and few post-cranial bones are available for checking the sexes of the remaining specimens, it is felt that a very high degree of accuracy of sexing (at least 90-95 per cent.) was obtained.

The crania used all appear to be from full-blooded Australian Aborigines, but the possibility of some being slightly hybridised can not be ruled out as, with very few exceptions, the specimens were recovered or excavated from unmarked graves or burials.

The specimens assembled for this study come from the collections of the Australian Museum, Sydney, and the Macleay Museum and Department of Anatomy, University of Sydney. Thanks are due to the above Institutions for the loan of material and also to the Division of Forensic Medicine, Department of Public Health, N.S.W., for the donation of a considerable number of specimens to the Department of Anatomy collection.

METHODS

A relatively small number of measurements (16) have been taken on each of the series of coastal N.S.W. crania. From these dimensions nine indices have been calculated for each of the crania. (The metrical features of the palate, mandible and teeth will be dealt with in a separate paper, together with the non-metrical features of those parts). The craniometric points, measurements and indices are basically those described by Martin and Saller (1957), but with a number of modifications, mainly derived from Stewart (1952), Buxton and Morant (1933) and Morant (e.g. 1927). These modifications were necessary partly because of certain distinctive features of the Aboriginal skull, but also to make the measurements comparable to those of Hrdlicka (1928). The definitions of the measurements and indices are given in Appendix 1.

In all of the statistical tables, males and females have been treated separately and in the first analysis (Tables 1-4), the material of each sex has been further subdivided into a northern, central and southern group. Figs. 1 and 2 show the boundaries of these groups and the actual localities of the specimens used. The central group (Broken Bay to Port Hacking) covers a relatively short length of coast, approximately 40 miles, compared to 400 miles for the northern group and 250 miles for the southern group. This arrangement was unfortunately necessary in order to build up the numbers in the northern and southern groups. Comparisons between the material in these three groups for each sex have been made (Figs. 3, 4 and 5) and the findings are discussed. Finally, the basic statistics of the measurements (Table 5) and the indices (Table 6) for all of the males and all of the females separately, from the whole of coastal N.S.W., were calculated. These latter figures include the northern, central and southern groups, plus another 13 crania received after the initial analysis had been completed.

In each group in the various tables, the mean ($\bar{x}$), number of specimens (N), standard deviation (s), standard error of the mean ($s_{\bar{x}}$), coefficient of variation (V) and observed range (O.R.) are given for each measurement or index.

ANALYSIS OF DATA

The basic statistics of the various measurements are given separately for the northern, central and southern groups in Table 1 (males) and Table 2 (females). The amount of variation of each character in a sex of each of the three groups is not

TABLE 1. *Male coastal N.S.W. Aboriginal crania:* Basic statistics of the measurements (in mm.) for northern, central and southern groups.

Group and Statistic	Max. cran. length	Max. cran. br.	Basi-breg. ht.	Basion -alv. pt.	Basion to nasion	Bizygo -maxil.	Bi-zygion	Supra-orbital br.	Min. frontal br.	Nasion -alv. pt.	Nasion to nariale	Nasal br.	Orb. br.	Orb. ht.	Maxil. alv. length	Maxil. alv. br.
NORTH																
N	15	14	13	10	14	11	7	14	14	11	12	12	14	13	11	15
$\bar{x}$	186.67	131.36	133.31	104.00	101.29	92.18	132.43	110.36	97.57	68.82	48.83	28.48	38.98	34.21	59.64	67.87
s	5.79	6.05	4.77	3.80	3.45	6.88	6.24	3.34	3.32	4.42	3.30	2.91	1.41	2.16	2.46	3.25
$s_{\bar{x}}$	1.49	1.62	1.32	1.20	0.92	2.07	2.36	0.89	0.89	1.33	0.95	0.84	0.37	0.60	0.74	0.84
V	3.10	4.60	3.58	3.65	3.41	7.47	4.71	3.03	3.40	6.43	6.75	10.21	3.60	6.31	4.13	4.79
O.R.	196	142	141	111	107	103	138	116	103	76	53	34.7	41.0	37.9	63	72
	175	123	128	98	94	83	122	105	91	59	42	23.3	36.7	30.9	56	61
CENTRAL																
N	30	27	27	23	27	21	10	28	29	23	24	27	25	25	25	30
$\bar{x}$	185.70	133.55	134.19	103.13	100.55	92.62	134.20	110.14	96.52	69.48	50.29	27.14	39.20	33.60	61.12	68.17
s	6.94	3.62	4.36	5.05	4.31	3.87	3.19	3.47	4.53	3.19	2.42	1.73	1.39	1.86	3.21	2.57
$s_{\bar{x}}$	1.27	0.70	0.84	1.05	0.83	0.84	1.01	0.66	0.84	0.67	0.49	0.33	0.28	0.37	0.64	0.47
V	3.74	2.71	3.25	4.89	4.29	4.17	2.38	3.15	4.70	4.59	4.82	6.39	3.54	5.54	5.24	3.78
O.R.	200	140	143	112	110	104	140	120	105	74	55	31.5	41.6	37.4	66	75
	171	127	126	94	94	85	129	105	86	65	45	23.4	36.6	30.4	56	63
SOUTH																
N	11	10	9	6	9	8	7	11	11	7	10	10	9	9	6	9
$\bar{x}$	189.18	133.40	135.78	102.83	102.33	98.13	137.29	110.91	97.00	70.29	49.20	27.29	39.69	34.13	59.50	69.67
s	5.96	3.81	4.24	4.92	4.69	6.06	7.97	6.50	5.88	4.07	3.73	1.94	2.59	1.54	3.02	3.28
$s_{\bar{x}}$	1.80	1.20	1.41	2.01	1.56	2.14	3.01	1.96	1.77	1.54	1.18	0.61	0.86	0.51	1.23	1.09
V	3.15	2.85	3.12	4.78	4.58	6.17	5.81	5.86	6.06	5.79	7.59	7.10	6.52	4.50	5.07	4.71
O.R.	198	139	141	110	112	107	151	126	109	75	54	30.3	44.7	36.1	64	74
	179	127	128	96	97	87	126	106	91	65	42	24.4	36.7	31.7	56	65

TABLE 2. *Female coastal N.S.W. Aboriginal crania:* Basic statistics of the measurements (in mm.) for northern, central and southern groups.

Group and Statistic		Max. cran. length	Max. cran. br.	Basi-breg. ht.	Basion -alv. pt.	Basion to nasion	Bizygo -maxil.	Bi-zygion	Supra-orbital br.	Min. frontal br.	Nasion -alv. pt.	Nasion to nariale	Nasal br.	Orb. br.	Orb. ht.	Maxil. alv. length	Maxil. alv. br.
NORTH	N	9	8	8	7	8	7	8	9	9	7	8	8	8	8	9	10
	$\bar{x}$	177.22	129.37	131.00	99.71	96.50	85.71	125.63	103.89	93.67	62.14	44.75	25.24	37.11	32.35	56.22	63.20
	s	6.12	3.66	4.63	3.25	4.14	3.59	4.31	2.67	3.28	3.62	2.37	1.10	1.59	2.86	3.03	3.58
	$s_{\bar{x}}$	2.04	1.29	1.64	1.23	1.46	1.36	1.52	0.89	1.09	1.37	0.84	0.39	0.56	10.01	1.01	1.13
	V	3.45	2.83	3.53	3.26	4.29	4.19	3.43	2.57	3.50	5.83	5.31	4.37	4.28	8.83	5.39	5.67
	O.R.	185	133	136	106	101	90	131	107	98	69	49	26.3	38.9	36.9	62	71
		169	123	124	97	90	82	118	100	88	58	42	23.0	35.2	29.1	52	58
CENTRAL	N	18	17	15	14	15	16	8	16	16	15	18	18	18	18	15	17
	$\bar{x}$	178.61	129.29	129.73	101.14	96.87	87.44	124.50	103.06	92.13	65.53	46.94	25.89	37.92	33.18	60.00	62.82
	s	6.55	4.10	5.02	5.27	3.68	5.25	4.31	2.46	3.16	3.81	2.36	1.60	1.55	1.49	2.62	2.72
	$s_{\bar{x}}$	1.55	0.99	1.30	1.41	0.95	1.31	1.52	0.61	0.79	0.99	0.56	0.38	0.37	0.35	0.68	0.66
	V	3.67	3.17	3.87	5.21	3.80	6.01	3.46	2.39	3.43	5.82	5.03	6.17	4.09	4.49	4.36	4.33
	O.R.	188	136	140	111	104	98	130	108	96	71	50	28.5	39.9	36.0	64	67
		166	122	122	94	91	80	116	98	87	58	42	23.3	35.3	29.4	56	58
SOUTH	N	10	10	9	8	9	9	4	10	10	9	10	10	8	8	8	9
	$\bar{x}$	180.20	130.60	130.55	97.00	96.00	92.44	126.00	104.50	93.00	64.22	47.80	25.29	37.50	33.70	57.13	63.22
	s	6.61	5.32	3.61	3.16	4.21	3.78	3.74	4.79	3.86	2.63	2.70	0.88	1.48	1.77	1.73	2.63
	$s_{\bar{x}}$	2.09	1.68	1.20	1.12	1.40	1.26	1.87	1.51	1.22	0.88	0.85	0.28	0.52	0.63	0.61	0.88
	V	3.67	4.07	2.76	3.26	4.39	4.09	2.97	4.58	4.15	4.10	5.65	3.48	3.94	5.26	3.02	4.17
	O.R.	191	140	134	101	102	98	131	109	99	67	54	26.9	40.1	36.5	60	67
		170	121	122	92	89	87	122	96	86	60	45	23.8	35.8	31.6	54	58

unduly great. There are only two rather high values for the coefficient of variation, nasal breadth in the northern males and orbital height in the northern females, and even these are not excessively high. Inspection of the mean values in Tables 1 and 2 shows few differences of considerable size between the characters in males or females of adjacent areas. The only measurements showing fairly large differences are: bizygomaxillare between central and southern males and the females from the same two groups: basion-alveolar point between central and southern females; maximum cranial length between central and southern males; maxillo-alveolar length between northern and central, and central and southern females; nasion-alveolar point between northern and central females. None of the above differences seem of particular importance taken on their own and no group in the males or in the females is larger in all its dimensions than any other group of the same sex. Further, it is not immediately obvious on comparison of the mean figures if the crania of one group are larger than those of any other group of the same sex in the majority of their mean dimensions or in average overall size.

To assess the size relationships between the crania of the three groups in each sex, the following techniques were used:—

(*a*) For each character, values of 3, 2 and 1 were assigned to the groups having the largest, middle and smallest mean dimensions respectively. These values were then totalled separately for males and females of each group, and the three sets of figures for each sex were subtracted in pairs. The resulting inter-relationships are shown in Fig. 3, in which the directions of the arrows indicate smaller to larger values and the included figures are the actual differences found.

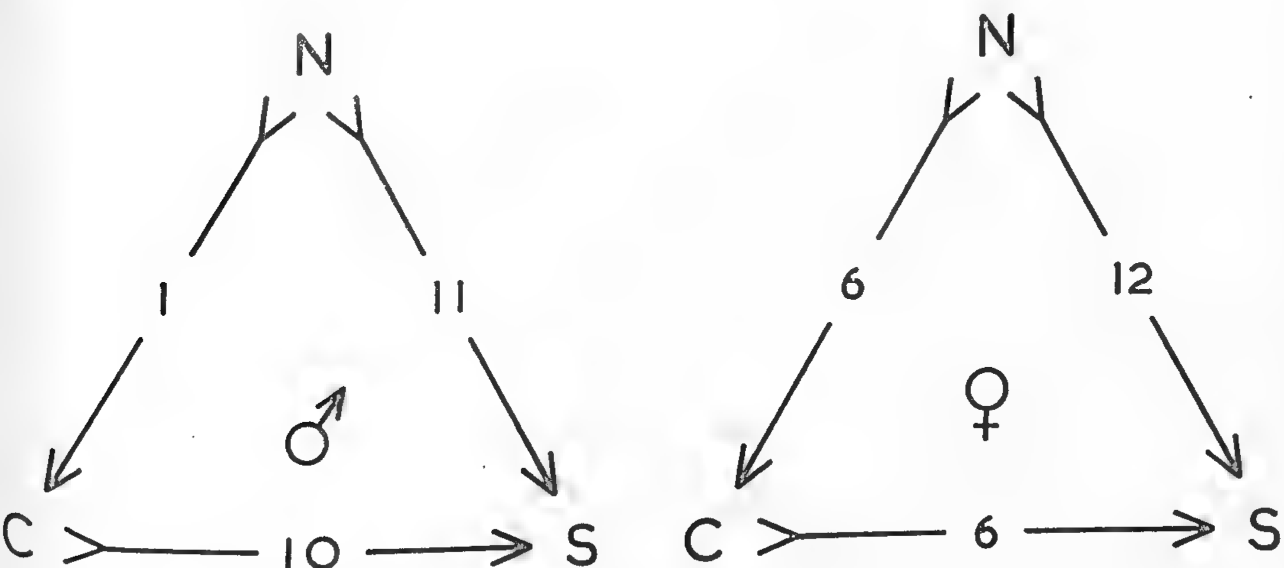

Figure 3— Inter-relationships between northern, central and southern groups of males and females, using 3, 2, 1 weighting for largest, middle and smallest mean values.

(*b*) Using a modification of Czekanowski's method (1909), the mean values of a character for each of the three groups of a sex were subtracted in pairs, the subtraction always being made in the same direction, e.g., southern minus central. Positive and negative figures thus resulted. The differences for all the characters of each pair in each sex were then totalled separately. These results are shown in Fig. 4, where the arrows again indicate smaller to larger values and the included figures are the differences.

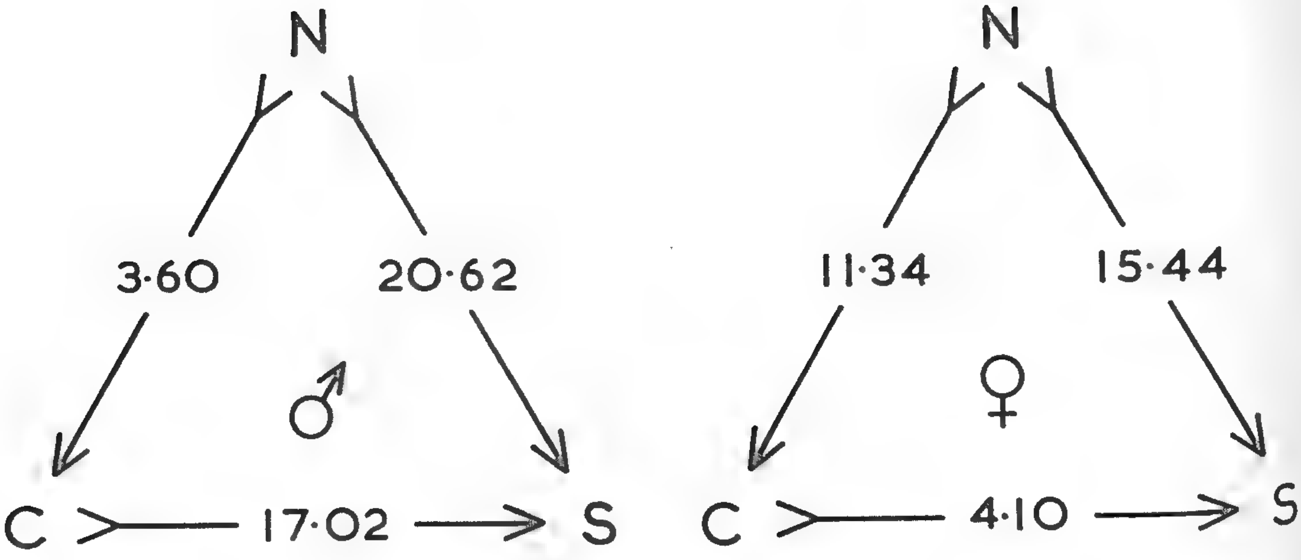

Figure 4— Inter-relationships between northern, central and southern groups of males and females using modified Czekanowski method.

(*c*) Employing a variation of Clarke's extension of the coefficient of divergence (Clarke, 1952), the difference for each character between each pair obtained in (*b*) above by subtracting the two relevant means was multiplied by two and then divided by the sum of the same two means, i.e., $2(\bar{x}_1 - \bar{x}_2)/(\bar{x}_1 + \bar{x}_2)$. The resulting figures for each pair of groups in each sex were totalled, taking cognizance of the signs. Using the same system described above (*b*), these figures were diagrammed in Fig. 5.

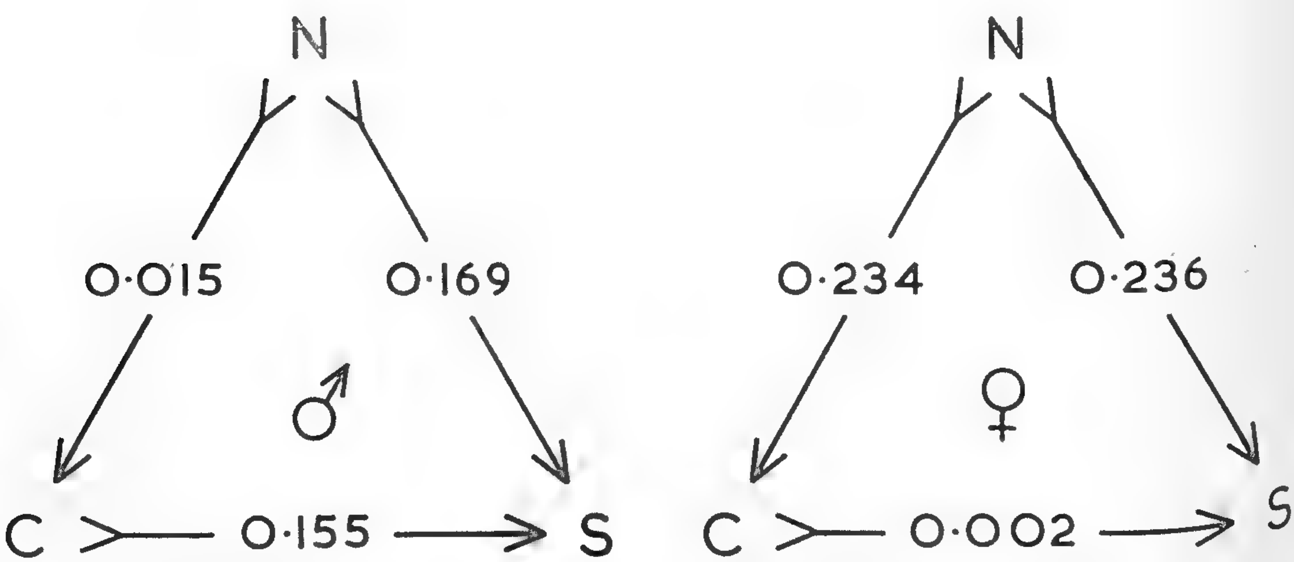

Figure 5— Inter-relationships between northern, central and southern groups of males and females, using modified extension of coefficient of divergence.

Each of the six results indicates a similar basic set of inter-relationships between the three groups: Thus, on number of larger characters and overall mean size, in both males and females, northern < central < southern. In the male comparisons, the central-northern group difference is far smaller than the southern-central group difference by all three methods—although the relative difference by method (*b*) is only about half of that found by methods (*a*) and (*c*). In the females the three methods give different relative results for the central-northern to southern-central group relationships. This appears to be mainly due to the very low figure for the basion-alveolar point dimension in the southern group and the rather high figure for the maxillo-alveolar length measurement in the central group. However, assessing the female results as they stand, by methods (*b*) and (*c*) the central-northern group difference is greater than the southern-central figure. This is the exact opposite to the result found for the males. Even assuming method (*a*) to give a better set of inter-relationships between the three groups in the females, there is still only equality between the central-northern and southern-central figures for this sex.

In addition to the above methods of analysis, the conventional form of Czekanowski's method (1909) was used to compare the crania of the three groups. By this method the "direction" of the differences between the pairs of groups for each character is ignored (smaller is always subtracted from larger) and the figure obtained by summing these differences is thus a measure of the *total* amount of difference between the two groups. This total difference figure is divided by the number of characters used to give the "durchschnittliche differenz", or DD as it is generally known. The results obtained for the three groups of N.S.W. crania were:—

Male:	northern-southern,	1.68;
	northern-central,	0.95;
	central-southern,	1.46.
Female:	northern-southern,	1.51;
	northern-central,	1.36;
	central-southern,	1.53.

From these results it can be seen that the northern-central figure is smaller than the central-southern figure for both males and females. This may at least in part be due to the distribution of the material (Fig. 1), as the majority of the northern specimens lie near to the central group, while those of the southern group are spread more evenly down the coast. The other point of interest is the fact that while the northern-central figure is smaller than the northern-southern in both sexes, northern-southern is greater than the central-southern in the males, but the reverse is true in the females.

In an attempt to analyze the data further, the six most northern male crania and the six most southern male crania were compared with each other and also with the rest of the male crania treated as a single central group. This approach gave a completely inconclusive result and in fact even failed to confirm the northern < central < southern finding described above. However, in view of there being only six specimens in each of the new northern and southern groups (and thus for most measurements five and in some cases only four specimens), this was perhaps not too unexpected.

Table 3 (males) and Table 4 (females) include the basic statistics of the indices calculated for the three groups separately. The mean indices are very similar for the three groups in both males and females. The greatest amounts of variation between the mean indices are found in the nasal and maxillo-alveolar indices in both males and females. Relationships between the indices of the three groups differ in the two sexes and are not clear even within each sex. No useful generalizations from the indices thus appear possible at this stage.

TABLE 3. *Male coastal N.S.W. Aboriginal crania:* Basic statistics of the indices for northern, central and southern groups.

Group and Statistic	Cranial	Length/height	Breadth/height	Cranial module	Upper facial	Orbital	Nasal	Maxillo/alveolar	Gnathic
NORTH									
N	14	13	12	12	5	13	12	11	10
$\bar{x}$	70.48	71.78	102.01	149.88	51.10	87.36	58.41	113.89	103.23
s	3.16	2.25	4.45	4.20	2.29	3.51	5.48	4.50	3.23
$s_{\bar{x}}$	0.85	0.62	1.28	1.21	10.3	0.97	1.58	1.36	1.02
V	4.48	3.13	4.36	2.80	4.49	4.02	9.38	3.95	3.13
O.R.	77.7	75.7	106.8	157.0	53.3	93.3	72.3	122.0	108.2
	66.7	68.9	94.2	144.0	48.4	82.0	52.9	107.0	99.1
CENTRAL									
N	27	27	24	24	9	25	24	25	23
$\bar{x}$	71.77	72.44	101.07	151.21	52.19	85.76	54.06	111.79	102.75
s	2.60	2.55	3.15	4.09	2.61	4.68	4.86	5.66	3.78
$s_{\bar{x}}$	0.50	0.49	0.64	0.83	0.87	0.94	0.99	1.13	0.79
V	3.62	3.52	3.11	2.70	5.00	5.46	8.99	5.06	3.67
O.R.	77.0	79.5	107.1	159.6	55.9	94.2	70.0	121.0	112.0
	66.7	69.4	95.0	143.6	48.6	76.2	45.0	100.0	97.9
SOUTH									
N	10	9	8	8	4	9	10	6	6
$\bar{x}$	70.30	72.12	101.34	153.04	49.87	86.15	55.65	117.43	101.50
s	3.00	2,02	3.75	3.69	1.76	3.93	4.57	9.82	4.52
$s_{\bar{x}}$	0.95	0.67	1.33	1.31	0.88	1.31	1.45	4.01	1.85
V	4.27	2.80	3.70	2.41	3.52	4.56	8.21	8.36	4.45
O.R.	74.3	74.9	109.4	158.0	52.5	89.9	63.3	130.3	106.1
	64.8	69.1	97.7	146.0	48.9	77.6	49.8	109.4	9.60

TABLE 4. *Female coastal N.S.W. Aboriginal crania:* Basic statistics of the indices for northern, central and southern groups.

Group and Statistic	Cranial	Length/height	Breadth/height	Cranial module	Upper facial	Orbital	Nasal	Maxillo/alveolar	Gnathic
NORTH									
N	8	8	8	8	7	8	8	9	7
$\bar{x}$	72.69	73.59	101.27	146.15	49.61	87.05	56.50	112.19	102.96
s	3.17	2.89	2.71	3.59	2.87	4.51	3.11	6.40	5.19
$s_{\bar{x}}$	1.12	1.02	0.96	1.27	1.08	1.59	1.10	2.13	1.96
V	4.36	3.92	2.67	2.46	5.78	5.18	5.50	5.70	5.04
O.R.	78.7	80.5	104.8	151.3	54.8	94.9	60.7	120.0	106.5
	68.7	71.6	96.1	141.3	47.3	81.9	52.3	101.7	97.0
CENTRAL									
N	17	15	14	14	7	18	18	14	14
$\bar{x}$	72.54	73.03	99.99	145.23	50.57	87.59	55.26	105.89	104.69
s	3.56	3.55	5.81	2.86	1.76	4.99	3.99	4.99	4.45
$s_{\bar{x}}$	0.86	0.92	1.55	0.77	0.67	1.17	0.94	1.33	1.19
V	4.90	4.87	5.81	1.97	3.48	5.69	7.22	4.71	4.25
O.R.	79.9	81.9	109.0	150.6	52.0	99.7	62.9	115.5	113.7
	66.3	66.5	89.7	141.3	46.8	79.7	46.6	96.9	97.9
SOUTH									
N	10	9	9	9	4	8	10	8	8
$\bar{x}$	72.52	72.89	100.23	146.70	51.20	89.87	53.00	110.75	100.59
s	3.10	2.69	4.93	3.80	2.31	3.01	2.52	4.80	2.78
$s_{\bar{x}}$	0.98	0.90	1.64	1.27	1.15	1.06	0.80	1.70	0.98
V	4.27	3.69	4.91	2.59	4.50	3.34	4.75	4.34	2.76
O.R.	76.5	76.5	110.7	152.3	53.2	94.8	57.1	117.5	104.2
	67.0	68.9	94.6	142.3	48.0	84.3	49.8	101.7	96.0

TABLE 5. *Male and female coastal N.S.W. Aboriginal crania:* Basic statistics of the measurements (in mm.) for whole region.

Group and Statistic	Max. cran. length	Max. cran. br.	Basi-breg. ht.	Basion -alv. pt.	Basion to nasion	Bizygo -maxil.	Bi-zygion	Supra-orbital br.	Min. frontal br.	Nasion -alv. pt.	Nasion to nariale	Nasal br.	Orb. br.	Orb. ht.	Maxil. alv. length	Maxil. alv. br.
MALE																
N	64	59	56	46	57	47	30	61	62	49	54	57	56	55	50	62
$\bar{x}$	186.77	133.20	134.46	103.37	101.30	93.19	134.80	110.41	97.06	69.14	49.67	27.43	39.33	33.81	60.38	68.19
s	6.44	4.52	4.70	4.37	4.09	5.34	5.62	4.12	4.38	3.67	3.11	2.05	1.61	1.99	2.93	2.79
$s_{\bar{x}}$	0.81	0.59	0.63	0.65	0.54	0.78	1.03	0.53	0.56	0.53	0.42	0.27	0.21	0.27	0.41	0.35
V	3.45	3.39	3.50	4.23	4.04	5.73	4.17	3.74	4.51	5.31	6.26	7.48	4.09	5.90	4.86	4.09
O.R.	200	142	144	112	112	107	151	126	109	76	56	34.7	44.7	37.9	66	75
	171	123	126	94	94	83	122	104	86	59	42	23.3	36.6	28.7	55	61
FEMALE																
N	43	41	38	34	38	38	25	41	41	36	42	42	40	40	37	42
$\bar{x}$	178.91	129.54	130.11	99.56	96.39	88.66	125.56	103.54	92.80	64.33	46.64	25.74	37.45	33.00	58.13	63.12
s	6.21	4.18	4.42	4.52	3.87	5.08	3.93	3.15	3.40	3.63	2.54	1.38	1.59	1.88	3.14	2.77
$s_{\bar{x}}$	0.95	0.65	0.72	0.77	0.63	0.82	0.79	0.49	0.53	0.60	0.39	0.21	0.25	0.30	0.52	0.43
V	3.47	3.23	3.39	4.54	4.01	5.73	3.13	3.05	3.66	5.63	5.44	5.35	4.25	5.69	5.40	4.39
O.R.	191	140	140	111	104	98	132	109	99	71	54	28.7	40.1	36.9	64	71
	166	121	122	92	88	80	116	96	86	58	42	23.0	34.7	29.1	52	58

TABLE 6. Male and female coastal N.S.W. Aboriginal crania: Basic statistics of the indices for whole region.

Group and Statistic	Cranial	Length/height	Breadth/height	Cranial module	Upper facial	Orbital	Nasal	Maxillo/alveolar	Gnathic
MALE									
N	59	56	51	51	24	55	54	50	46
$\bar{x}$	71.25	72.29	101.26	151.38	51.09	85.84	55.42	113.07	102.41
s	2.90	2.36	3.67	4.19	2.39	4.39	5.07	6.09	3.68
$s_{\bar{x}}$	0.38	0.31	0.51	0.59	0.49	0.59	0.69	0.86	0.54
V	4.07	3.26	3.63	2.77	4.67	5.12	9.15	5.39	3.60
O.R.	77.7	79.5	109.4	160.0	55.9	94.2	72.3	130.3	112.0
	64.8	68.9	93.4	143.6	46.0	75.9	44.6	100.0	96.0
FEMALE									
N	41	38	37	37	22	40	42	36	34
$\bar{x}$	72.40	72.90	100.39	145.91	50.61	88.17	55.31	109.22	103.28
s	3.14	2.91	4.52	3.33	2.65	4.36	3.57	6.01	4.46
$s_{\bar{x}}$	0.49	0.47	0.74	0.55	0.57	0.69	0.55	1.00	0.77
V	4.33	4.00	4.50	2.28	5.23	4.94	6.46	5.51	4.32
O.R.	79.9	81.9	110.7	152.3	56.9	99.7	62.9	120.0	113.7
	66.3	66.5	89.7	139.0	46.8	79.7	46.6	96.9	96.0

The measurements for all the male and all the female crania separately from the whole of coastal N.S.W. are statistically summarized in Table 5. Features which show the greatest differences between the means for the two sexes (as determined by male mean minus female mean divided by the male mean plus female mean) are: maxillo-alveolar breadth, nasion to alveolar point, bizygion, nasal breath, supra-orbital breath and nasion to nariale. The differences between the means of these six dimensions are, by the technique used, quite considerably more than those between any of the other features.

Table 6 lists separately the basic statistics of the indices for all of the male and female crania from the whole of coastal N.S.W. The mean indices are very similar in the two sexes except that the orbital index is greater in the females, reflecting the fact that the orbit is relatively high in that sex; the maxillo-alveolar index is greater in males, a result of the breadth dimension being considerably larger in the males; the cranial module is considerably larger in the males, as might have been expected. The gnathic index is only very slightly larger in the females.

DISCUSSION

As mentioned in the introduction, numerous studies of the Australian Aborigine have been made over the past 100 years and these include several in which metrical data on the cranium were recorded or/and analyzed. Prominent amongst these are the studies by Morant (1927), Hrdlicka (1928) and Wagner (1937). In these studies, the analyses generally consisted of comparisons between material from different whole states of Australia and comparisons of material from the whole of Australia with that from other areas. The results and conclusions from these are not always fully in agreement [e.g., Morant (1927) and Wagner (1937), who both compared metrical data by using the coefficient of racial likeness], but certain important results, such as the difference between crania from the Northern Territory and the rest of Australia, have emerged.

In the present paper an attempt has been made to study and compare groups of Aboriginal crania from more localized regions of Australia, bounded by natural geographic features and subdivided to facilitate the study of trends and inter-relationships. The region studied is bounded to the west by the Great Dividing Range and to the east by the sea. The northern and southern limits are the boundaries of N.S.W., but it is hoped to extend the study in both directions in the future. The three groups artificially defined from north to south within this narrow, natural, geographic region enable the cranial size relationships within the southern one-third of the east coast plain of Australia to be studied. The methods used for making comparisons between the data are of simple type and one of them is based on Czekanowski (1909). Huizinga (1962) has shown that Czekanowski's simple method can give results similar to those obtained by the more sophisticated statistical techniques.

The analysis of N.S.W. coastal Aboriginal crania made in this paper has shown that there appears to be a decrease in overall size of the cranium from south to north in the region sampled for both males and females. This finding suggests that continued micro-studies of this sort may reveal other informative clines or pockets which will give further pointers of value in the study of the origin and composition of the Australian Aborigines. It would not seem advisable to attempt to correlate the present findings with the main theories about the origin of the Australian Aborigine until they have been tested against the findings based on the non-metrical features of the skull and the metrical and non-metrical features of the jaws and teeth. Similarly, it does not seem that any useful purpose would be served at present by making comparisons with previously described data from whole States of Australia where micro-differences of the sort described in this paper would probably be obscured.

SUMMARY

1. Sixteen metrical features and nine indices of 65 male and 44 female Aboriginal crania from coastal N.S.W., Australia, have been studied in three sub-groups (northern, central and southern) and for the region as a whole.

2. An overall cranial size decrease from south to north was found.

3. The importance of analyzing and comparing physical anthropological data from small, geographically—or ecologically—meaningful areas of Australia is stressed.

ACKNOWLEDGEMENTS

This study was undertaken at the suggestion of Professor N. W. G. Macintosh, Department of Anatomy, University of Sydney. It is my pleasure to thank him for assistance at several points in the study and particularly for comments on the final draft of the paper. From the same Department, Mr. S. L. Larnach gave me considerable help while I was taking the measurements, Mr. B. C. Lockett assisted me with the statistical calculations, Mr. K. N. Smith drew the accompanying diagrams and Mrs. B. King prepared the typescript.

APPENDIX 1

(*a*) The following table summarizes the most important features of the measurements taken:—

Measurement	*Remarks*	*Instrument*
Maximum cranial length (L).	Maximum glabella-occipital length.	Spreading caliper
Maximum cranial breadth (B).	Maximum excluding temporal and supramastoid crests.	Spreading caliper.
Basi-bregmatic height (H′).	" Basion " = *lowest* median point on external surface of anterior margin (ectobasion). Bregma: where sagittal and coronal sutures depressed, point used was on frontal, just anterior to bregma.	Spreading caliper.
Basion-alveolar point (GL).	" Basion " = median point on the *internal* surface of the anterior margin (endobasion). " Alveolar point " = most *anterior* point between the median incisors (prosthion).	Spreading caliper
Basion-nasion (LB).	" Basion " = endobasion.	Spreading caliper.
Bizygomaxillare (GB)	Zygomaxillare = lowest point on suture between zygomatic and maxilla, externally.	Sliding caliper
Bizygion (J) (Bizygomatic).	Zygion = most lateral points on zygomatic arches	Spreading caliper
Supra-orbital breath (SOB).	Maximum breadth of brow ridges on the frontal bone	Sliding caliper
Minimum frontal (B′).	Minimum breadth between temporal crests	Spreading caliper
Nasion-alveolar point (G′H).	" Nasion " is often a depressed groove up to 1 mm. in breath-midpoint used. " Alveolar point " = *lowest* point between median incisors.	Sliding caliper
Nasion-nariale (NH).	Nariale = point where a tangent to lowest points on crista spinalis (paraseptal ridge) meets midsagittal plane (= nasospinale). The actual point used was usually just lateral to the nasal spine.	Sliding caliper
Nasal breadth (NB).	Greatest breadth of pyriform aperture.	Sliding int. caliper
Orbital breadth (O^1).	Dacryon = point of meeting of frontal, maxillary and lacrimal bones. Lateral orbital margin very much rounded. Point used was the *beginning* of the rounding *internally*.	Sliding int. caliper
Orbital height (O^2).	Maximum at right angles to breadth.	Sliding int. caliper
Maxillo-alveolar breadth (MA^1).	Maximum external breadth of palate on maxilla, usually at M^2.	Sliding caliper
Maxillo-alveolar length (MA^2).	Prosthion = most anterior point between median incisors. Tangent to posterior border of alveolar processes (maxillary tuberosities).	Sliding caliper

Notes on Measurements

(1) Where damage to an area to be measured was only slight, an estimate was made. An adjustment was also made at alveolar point (prosthion) when one I^1 was missing; when both I^1 teeth were missing no measurement was taken from this point.

(2) For the measurements of the orbits the left and right dimensions were averaged.

(3) Orbital breadth: This measurement was modified because of the greatly rounded orbital margin, and conforms with that taken by Hrdlicka (1928). The outer plane of the lumen of the orbit is aimed at by this author. Compared to the pencilled midline of the rounding, it was usually 1.5-2.5 mm. less. With this dimension, as in the case of most of the other modifications made above, the changes to the "standard" points and measurements were necessary because of the special anatomical features of the Aboriginal cranium.

(4) All measurements were taken to the nearest mm. except for nasal breadth, orbital breadth and orbital height, which were taken to the nearest 0.1 mm.

(*b*) **The following are the formulae of the various indices calculated:—**

Cranial: B/L x 100.
Length/Height: H′/L x 100.
Breadth/Height: H′/B x 100.
Cranial Module: L + B + H′ ÷ 3.
Upper facial: G′H/J x 100.

Orbital: o^2/o^1 x 100.
Nasal: NB/NH x 100.
Maxillo-alveolar: MA^1/MA^2 x 100.
Gnathic: GL/LB x 100.

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Sydney: V. C. N. Blight, Government Printer—1964

MEROSTOMOIDEA (ARTHROPODA, TRILOBITOMORPHA) FROM THE AUSTRALIAN MIDDLE TRIASSIC

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Plate 35. Figs. 1 and 2. Manuscript received August 28, 1963

SUMMARY

A monotypic genus of a new family of Merostomoidea is described from the Middle Triassic of Brookvale, New South Wales, Australia. The known range of the subclass, previously recorded from the Middle Cambrian, is extended considerably by this record.

Three well preserved non-insect arthropod specimens, apart from the xiphosuron, *Austrolimulus fletcheri* Riek, (1955), have been collected from the Middle Triassic freshwater sediments at Brookvale, New South Wales. These sediments also contain abundant insects and fish. These three specimens bear a considerable resemblance in body shape to both the Synziphosurina (Merostomata) and the Merostomoidea (Trilobitomorpha). The post-cephalic portion of the body is divided into two distinct regions and ends in a long caudal style. Although appendages are not clearly preserved, their general structure can be distinguished below the crumpled pleural regions in one of the specimens and their bases distinguished in another. These numerous pairs of similar appendages are of trilobitomorph form.

Trilobitomorpha, which are first recorded from the Lower Cambrian, are not known from strata younger than the Middle Permian and almost all the species occurring since the Cambrian are referred to the well-known trilobites (Class Trilobita). The Class Trilobitoidea is, however, recorded from the Devonian as well as from the Cambrian. If these Middle Triassic specimens do belong to the Trilobitoidea they extend the known range of the class very considerably. There seems little doubt from a study of the insect remains that the sediments in which these specimens occur are of Triassic, very probably Middle Triassic, age.

Trilobitoidea have not previously been recorded from Australia though the Trilobita are well represented. The only Synziphosurina (Merostomata) known from Australia is *Hemiaspis tunnecliffei* Chapman (1932) from the Silurian at Studley Park, Victoria. This specimen is so poorly preserved that its affinities are obscure.

Because of the considerable time interval between the Middle Triassic and the previous records of Trilobitoidea (Moore, 1959) doubts were originally entertained that these specimens could be representatives of this class of Trilobitomorpha. The specimens were therefore compared with other arthropod groups. There is a superficial resemblance between one specimen and the aquatic larvae of some Coleoptera (Insecta). This resemblance is due mainly to distortion of the fossil which was apparently brought about during the death struggles of the specimen. It would appear that the specimen was trapped in drying mud and that as it tried to move

forward the thin pleural regions became wrinkled and partly swept back along the sides of the body. This gives the specimen the appearance of possessing abundant lateral abdominal gills whereas one is actually seeing a rough outline of the serially arranged trilobitomorph legs through the wrinkled pleural lobes. The stylate telson can be compared with the apically produced abdomen of some water-beetle larvae (Coleoptera, Dytiscidae). In other specimens which are not distorted, the subdivision of the body into two very different regions gives it an appearance more like that of certain branchiopod Crustacea.

The most distinctive feature of the species is the development of a partly fused dorsal shield covering most of the trunk segments. The sessile eyes are well developed and the antenna was apparently formed of a number of large flattened segments.

Subphylum **TRILOBITOMORPHA**

Class **Trilobitoidea**

Subclass **Merostomoidea**

Family **Synaustridae** fam. nov.

Trilobitomorpha with elongate, trilobed body, styliform telson and all appendages, apart from the antenna, apparently of a simple trilobitic type. The post-cephalic portion of the body is differentiated into a broad anterior region with well developed pleura and a narrow posterior region without obvious pleura and without appendages. A partly fused dorsal shield is developed on the anterior trunk segments.

The family is recorded from the Middle Triassic of Australia.

Synaustrus gen. nov.

Type species **Synaustrus brookvalensis** sp. nov.

Cephalon rounded anteriorly and with the genal spine not strongly produced. Glabella large and with the suggestion of transverse segmentation which may, however, be due to segmentation on the ventral surface. Eye large, situated at the lateral margin. Trunk appearing to consist of nine segments but the first five segments each of a composite nature, consisting of 1,2,3,3,2 segments respectively, with the possibility of the first portion consisting of two segments. This dorsal shield may be ankylosed but the well developed junctions would seem to indicate some freedom of movement. The posterior four trunk segments free, without obvious pleura. Body ending in a long caudal style. Trunk appendages (absent from the posterior four segments) not extending beyond the pleural margins of the anterior segments.

This genus can be compared with *Molaria* Walcott from the Middle Cambrian, from which it differs in the development of a partly fused dorsal shield from the anterior trunk segments and apparently in possessing a larger number of trunk segments.

Synaustrus brookvalensis sp. nov.

Holotype specimen, F.30953, entire except for apex of telson but with the pleural regions of the trunk distorted. Length, excluding terminal style, 40 mm. Cephalon with genal spine produced to only a small blunt spine, grooved above. "Free cheek" narrowing only slightly anteriorly. Glabella, though ill-defined, somewhat longer

than wide, with a small elongate tubercle at meson caudally; with the suggestion of transverse grooves though this may be due to structures on the ventral side. Eye well developed, situated at lateral margin, at junction of anterior and middle thirds of cephalon; apparently slightly elongate.

Anterior portion of trunk appearing to consist of five segments each with well developed pleura, but in fact consisting of 11 or 12 segments between which there is part fusion dorsally. Ventrally each segment has a distinct sternite and a pair of lateral appendages. Each of these five apparent segments has a median elongated tubercle towards its posterior margin. Laterally, but just within the margin of the body (at junction of pleura with the body), the insertions of the appendages appear as a row of distinct pits. One pit appears at the caudal margin of the cephalon. A varying number occur on each of the following apparent trunk segments. One pit is present on the first segment and then 2,3,3,2. Appendages, seen through the crumpled pleura, consisting of a series of small segments, apparently up to 10 in number. Running obliquely back and towards the meson there is a deep groove from the insertion of each appendage. These grooves are considered to be artifacts produced by the flattening of the sclerotised body segments. (Such artifacts occur also in fossil insect nymphs where their true nature can be ascertained by comparison with the nymphs of recent species.) Pleural margins of the components of the dorsal trunk-shield not produced postero-laterally to any marked extent. Caudal four trunk segments much narrower than anterior segments; lateral margins not produced; each with a median elongated tubercle; segments subequal, but terminal segment tapering slightly. Caudal style with a median longitudinal crest.

The structure of the cephalon is difficult to interpret for apparently some structures on both the dorsal and ventral surfaces are preserved. It is considered that the anterior doublure or labrum is preserved. The margins of this median structure are thickened and so are clearly defined. The labrum is more or less rectangular in outline. Arising from the region of the postero-lateral corner of the labrum there is a broad but elongated, laterally-directed segment which extends to partly cover the eye. This is considered to represent the basal segment of the antenna. A much enlarged somewhat paddle-shaped segment lies over the genal area and on the first three " segments " of the trunk shield there are smooth flattened areas that most probably are indications of more-distal segments. The indications of segmentation in the glabella are most probably faint sutures between the cephalic sternites. This would indicate the presence of at least three cephalic segments behind the antennae. There are no clear indications of appendages on these segments, though grooves on the genal area close to the caudal margin of the cephalon may be indications of their presence.

A second, slightly larger specimen, F.30969, lacks the caudal style and posterior two segments of the trunk; preserved portion 43 mm. It preserves more clearly the ventral surface but the elongated tubercles of the dorsal trunk shield are clear as, too, are the insertions of the appendages. These two structural landmarks allow a direct comparison between the specimens. Sternites transverse, their surface very finely shagreened; the anterior sternites with straight margins but the eighth to the eleventh sternites with margins distinctly concaved from behind; the margins of the most posterior sternites much more concave than the corresponding tergite margins. The insertion of the appendages midway between anterior and posterior margin and slightly closer to the lateral margin of the sternite; appendages not preserved. The first defined sternite appears below the junction between the cephalon and trunk (as it did in the holotype). If this sternite belongs to the trunk segments it would seem that there are two segments incorporated in the first component of the trunk shield to give a total of 16 trunk segments.

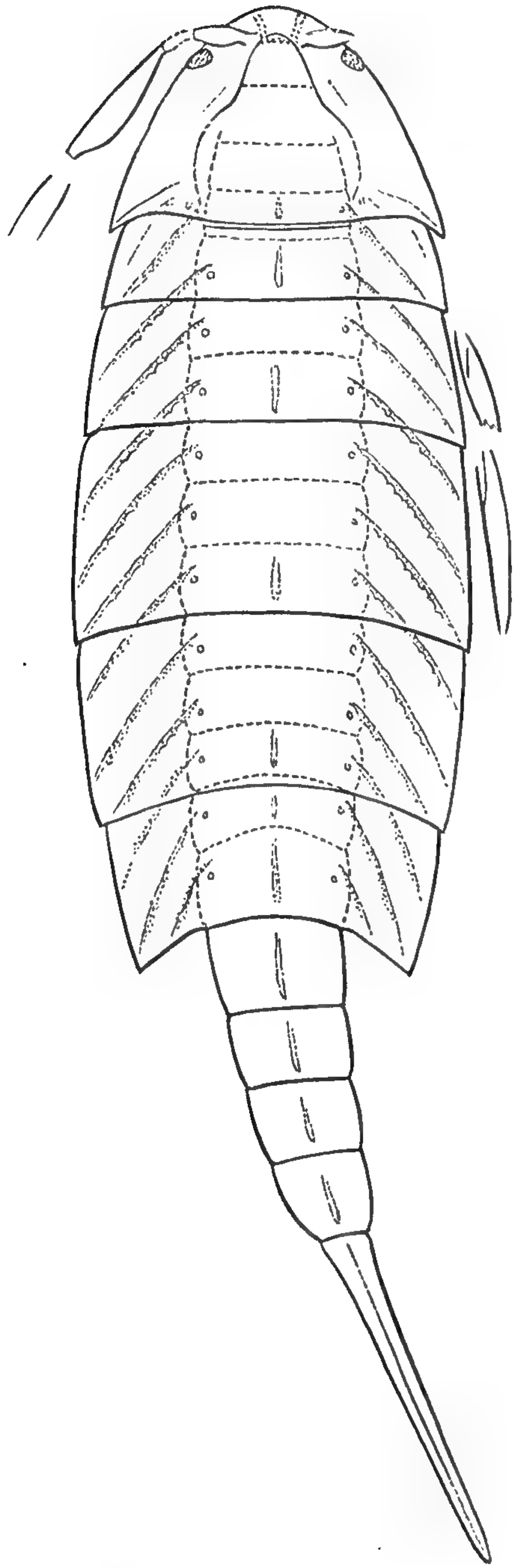

Figure 1: Part reconstruction of *Synaustrus brookvalensis* gen. et sp. nov. based on holotype. F.30969 and the unregistered specimen of Figure 2.

The third specimen, known at present only from a photograph, is preserved as an undistorted dorso-ventral compression but it lacks the caudal style and possibly the last trunk segment. The outline of the gut is clearly distinguishable in the trunk, especially over the anterior portion. It is a straight tube without diverticula. The trunk shield is very clearly preserved. The lateral margins of its components are not strongly produced. Its pleural regions appear grooved, with the grooves continued from one section of the shield to the next. This grooving is most probably an artifact produced by the appendages which apparently lie below the raised areas and parallel to the grooves. The basal insertions of the appendages are clearly preserved.

Types: Holotype F.30953 and paratype F.30969 in the Australian Museum, Sydney.

Type locality and horizon: Beacon Hill shales of the Hawkesbury Series, Middle Triassic, at Brookvale, near Sydney, New South Wales.

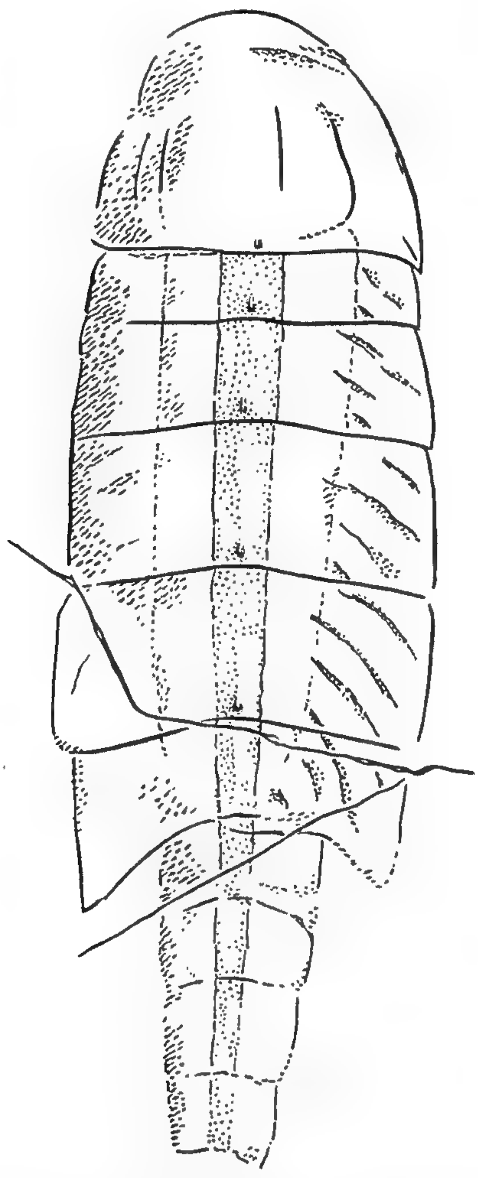

Figure 2: Unregistered specimen, location not known, of *Synaustrus brookvalensis* gen. et sp. nov., showing outline of gut and undistorted pleural regions.

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EXPLANATION OF PLATE

Plate 35: *Synaustrus brookvalensis* gen. et sp. nov.

1. F.30953, holotype, length 40 mm., with indications of the appendages under the crumpled pleura.
2. Photograph of specimen, location unknown, complete except for caudal style, showing undistorted pleural regions.
3. Portion of Figure 2, with reversed lighting, to show bases of appendages.

Sydney: V. C. N. Blight, Government Printer—1964

SOME NEPHTYIDAE (POLYCHAETA) FROM AUSTRALIAN WATERS

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Figures 1-4 Manuscript received, November 30, 1963

During a stay at the Allan Hancock Foundation, University of Southern California, U.S.A., made possible by a grant from the Norwegian Research Council for Science and the Humanities, I had the opportunity to study a small collection of nephtyids from Australian waters sent to Dr. Olga Hartman by Mr. S. J. Edmonds, University of Adelaide, South Australia, Miss Isobel Bennet, the Australian Museum, Sydney, and Miss Barbara Dew, School of Public Health and Tropical Medicine, Sydney. I wish to express my gratitude to Dr. Olga Hartman for giving me the opportunity to study this collection and for all her help and advice during my stay at the Allan Hancock Foundation. I also wish to thank Mr. Anker Petersen for preparing the drawings.

The following summarizes the reports of nephtyids from Australian waters. The large report of Augener (1913) named only one, *Nephtys gravieri*, from Fremantle, Western Australia. Benham (1915, 1916) reported *Aglaophamus macroura* (Schmarda) 1861 from southern Australia. Augener (1922) reported and redescribed *Aglaophamus dibranchis* (Grube) 1878 from one specimen from southern Australia and later Augener (1927) reported *N. gravieri* and *A. dibranchis*? from Western Port, Victoria, and Disaster Bay respectively.

Key to Australian Species

1. Interramal cirri recurved .... Nephtys 2
   Interramal cirri involute .... Aglaophamus 4
2. Proximal surface of proboscis smooth .... *N. gravieri* Augener 1913
   Proximal surface of proboscis with prickles 3
3. Interramal cirri present from setiger 3; median acicular lobes broadly incised (Fig 3) .... *N. mirocirris* n. sp.
   Interramal cirri present from setiger 4; median acicular lobes not incised (Fig. 1) .... *N. australiensis* n. sp.
4. Superior edge of the anterior neuropodia with a long erect lobe; notopodial cirri digitiform .... *A. dibranchis* (Grube) 1878
   Superior edge of the anterior neuropodia with a small erect lobe; notopodial cirri foliaceous .... A. macroura (Schmarda) 1861

Nephtys australiensis n. sp.

(Figures 1, 2)

Collection.—Holotype: Port Vincent, Yorke Peninsula, South Australia, sand. Paratypes: Port Vincent, Yorke Peninsula, South Australia, sand (5 specimens). Zostera roots, Stansbury, Yorke Peninsula, South Australia (2). Mudflat north of Salt Creek, Yorke Peninsula, South Australia (1). Zostera roots, Port Vincent, Yorke Peninsula, South Australia (1). Marine Biological Laboratory, Cronulla, probably intertidal (1). Camp Cove, Port Jackson, N.S.W., October 10, 1950, in 3 to 4 fms., rubbly bottom (1).

The holotype is deposited in the Australian Museum, Sydney; paratypes and others are in the Allan Hancock Foundation, Los Angeles, California, and in the Biological Station, Espegrend, Blomsterdalen, Norway.

The holotype is a complete specimen with proboscis half extruded; it measures 45 mm. in length and 2 mm. in width and consist of 88 segments. The prostomium is pentagonal, longer than wide with the widest part in the anterior third. First antennae are short and blunt; second are about twice as long as the first and digitiform. No eyes could be made out. Nuchal papillae are present but small.

The proboscis, from another specimen, is slightly clavate with 22 rows of subterminal papillae and 5 to 6 papillae in each row. A median dorsal papilla is present. The proximal surface of the proboscis is covered with minute prickles.

The notopodial acicular lobe in the first setiger is conical; the other lobes and the notopodial cirrus are reduced. The neuropodial acicular lobe is short and rounded and the neuropodial cirrus is short and blunt. Fully developed parapodia at the twentieth setiger (Fig. 1) have both acicular lobes symmetrically conical. Both preacicular lobes are small but distinct and rounded. The notopodial postacicular lobe is longer than its corresponding acicular one; it is narrow, rectangular with its longest axis nearly lateral and is placed behind and dorsal to the acicular lobe. In the neuropodium the postacicular lobe is evenly rounded, nearly symmetrically placed behind the acicular lobe and longer than that lobe. The notopodial cirrus is truncate foliaceous, reaching the same length as the postacicular lobe. In the posterior part of the body this cirrus becomes narrower and in the last setigers is slender, digitiform. The neuropodial cirrus is digitiform.

The interramal cirrus is present from setiger 4 and continued to the end of the body. Each is large, thickset, with a well marked basal swelling, but no digitiform lobe. It may fill the space between the notopodium and neuropodium completely.

The setae are of three kinds; the preacicular fascicle has a few barred setae and more numerous geniculate setae with fine denticles at the cutting edge. The postacicular fascicle has only coarsely denticled geniculate setae with the denticles in a single row at the cutting edge (Fig. 2).

N. australiensis differs from *N. gravieri* Augener in the following characters: the proximal surface of the proboscis is covered with prickles in the first, a feature not mentioned for the second. The preacicular lobe is a distinct free lobe in the first and rudimentary in the second. The notopodial cirrus is broad, foliaceous in the first and digitiform in the second. The interramal cirri are large and recurved in the first and short and thickset in the second. Augener (1927) p. 116 described some specimens with "Die Dorsalcirren sind öfter nahezu eiförmig im Umriss"; this may refer to a second species, possibly *N. australiensis*.

Day (1953) described *N. capensis* from South African waters. It differs from both *N. australiensis* and *N. mirocirris* in the shape of the notopodial cirri and in the texture of the proximal part of the proboscis; this is smooth in *N. capensis* and prickled in both *N. australiensis* and *N. mirocirris*.

N. australiensis differs from *N. mirocirris* in the following characters: a median papilla is present on the proboscis in the first, lacking in the second; interramal cirri are present from setiger 4 in the first and from setiger 3 in the second; a small digitiform lobe on the superior edge of the interramal cirri is lacking in the first and present in the second. A unique feature in *N. mirocirris* is the character of the notopodial and neuropodial acicular lobes, which are broadly incised, the aciculum emerging from the inner convexities (Fig. 3).

Nephtys mirocirris n. sp.

(Figures 3, 4)

Collection.—Holotype: Clinton, Yorke Peninsula, South Australia, sand. Paratypes: Clinton, Yorke Peninsula, South Australia, sand, (6 specimens). Corney Point, Yorke Peninsula, South Australia (1).

The holotype is deposited in the Australian Museum, Sydney; paratypes are in the Allan Hancock Foundation, Los Angeles, California, and in the Biological Station, Espegrend, Blomsterdalen, Norway.

The description is based on the holotype; this is a complete specimen with 95 setigers, about 60 mm. long and 4 mm. wide. The prostomium is rounded rectangular with a nearly straight front. The first antennae are slender; the second about twice as long as the first and slender. There are some dark spots (eyes?) present on the dorsal side of the prostomium. Nuchal papillae are prominent.

The proboscis is cylindrical; the proximal surface is covered with minute prickles. The subterminal papillae are arranged in 22 rows with 5 to 7 papillae in each row. There is no median papilla.

The acicular lobe is conical in the notopodium of the first setiger; pre- and postacicular lobes and the notopodial cirrus are rudimentary. The acicular lobe in the neuropodium is very small and button-shaped; the neuropodial cirrus is well developed and digitiform. The notopodial acicular lobe in the fully developed parapodia is broadly incised with the aciculum emerging from the inferior convexity; both parts of the lobe are of about the same size and conical (Fig. 3). A similar incision is present in the neuropodial acicular lobe, but the inferior convexity is very small compared to the corresponding notopodial convexity. The notopodial preacicular lobe is well developed and rounded; the neuropodial preacicular lobe is rounded oval. The notopodial postacicular lobe is rounded, best developed on the dorsal side. The postacicular lobe in the neuropodium is nearly twice as long as the acicular lobe, somewhat asymmetrically rounded. The notopodial cirrus is rather long, digitiform; the neuropodial cirrus is digitiform. The pre- and postacicular lobes in both neuropodia and notopodia diminish in the posterior part of the body, in the last few setigers they are only small folds on each side of the acicular lobe. The incision in the acicular lobes is only distinct from setigers 15 to 40. The acicular lobes tend to get increasingly pointed in the hindmost setigers.

The interramal cirri are present from setiger 3 and continued to the last setigers. Each is comparatively short and stout, never fills the space between the notopodium and the neuropodium. A small digitiform lobe is present on the superior side near the base of all cirri.

A few barred setae are present in the notopodial preacicular fascicle near the inferior end; corresponding setae are present near the superior end in the neuropodial preacicular fascicle. Besides these both preacicular fascicles consist of slender, slightly geniculate setae with fine denticles. Coarse, slightly geniculate setae with one row of large denticles are present in both postacicular fascicles, besides a few slender setae with fine denticles as in the preacicular fascicles (Fig. 4).

In most respects the specimens agree with *N. gravieri* Augener 1913. They differ from the latter in the presence of the deep incision in the acicular lobes and in the presence of prickles on the proximal surface of the proboscis, both features presumably lacking in *N. gravieri*. See also discussion under *N. australiensis*.

Nephtys gravieri Augener, 1913

Nephthys gravieri Augener 1913, pp. 123-125, Pl. II, fig. 5, Text fig. 6 a-c, Fremantle.

Nephthys gravieri Augener 1927, p. 116, Western Port, Victoria.

No specimens are available. *N. gravieri* is best known through its original description. Fauvel (1932) reported *N. gravieri* from India. His description, though brief, of the interramal cirri shows that he must have found *N. gravieri* or a closely related species. From the same description it is clear that it can have been neither *N. australiensis* nor *N. mirocirris*. Fauvel (1953) repeated the same description and gave, in addition, some drawings. His Fig. 114a of a prostomium was copied from Augener (1913) Pl. II, fig. 5, but his Fig. 114b of a parapodium is not that of *N. gravieri* as given in Augener (1913) Text fig. 6c.

Aglaophamus dibranchis (Grube) 1878

Nephthys dibranchis Augener 1922, pp. 17-20, Fig. 5, south-east Australia, New South Wales.

Nephthys dibranchis Augener 1927, pp. 116-117, Disaster Bay, New South Wales.

Aglaophamus dibranchis Hartman 1950, p. 121, redescription.

No specimens are available. The species is redescribed in Augener (1922) and in Hartman (1950).

Aglaophamus macroura (Schmarda) 1861

Nephthys macrura Benham 1915, p. 176, south of Australia?

Nephthys macrura Benham 1916, p. 130, east-north-east of Babel Island, Bass Strait, 1,200 fms.

Nephthys macrura Augener 1927, p. 116, Bass Strait (Benham).

Aglaophamus macroura Hartman 1950, pp. 118-120, redescription.

No specimens are available. It has been reported from Bass Strait by Benham (1916) in 1,200 fms. The species was redescribed in Hartman (1950).

Aglaophamus virginis (Kinberg) 1866

Aglaophamus virginis Hartman 1953, pp. 30-31, Fig. 7 a-b, redescription.

Collection.—Macquarie Island Stations 57a and 58b (1 specimen from each). A.N.A.R.E. St. G 17/50, Heard Island, Atlas Cove, Camp Beach, August 18, 1950 (5).

This species has not been reported from Australia, but was present in the collection from Antarctic and sub-Antarctic waters. According to Hartman (1953) *A. virginis* differs from *A. macroura*, with which it is closely related, in the following characters: the proximal surface of the proboscis is smooth in the first and finely tuberculated in the second; the superior edge of the neuropodium may be auriculate in the first, but is never developed as an erect digitiform lobe as in the second.

A. virginis seems to have a wide distribution in Antarctic waters. Because it has not been reported from Australia, it was not considered in the key to species.

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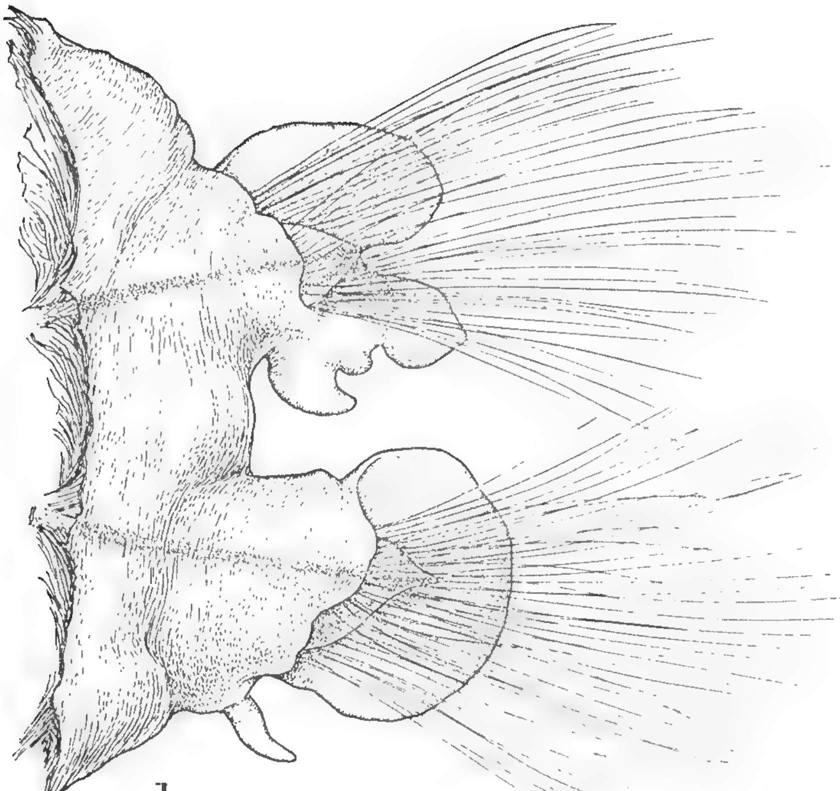
EXPLANATION OF FIGURES

Fig. 1. Nephtys australiensis, n. sp. 22nd parapodium in anterior view, x 41.

Fig. 2. Nephtys australiensis, n. sp. Denticled section of a postacicular seta, from same parapodium, x 437.

Fig. 3. Nephtys mirocirris, n. sp. 22nd parapodium in anterior view, x 68.

Fig. 4. Nephtys mirocirris, n. sp. Denticled section of a postacicular seta, from same parapodium, x 526.



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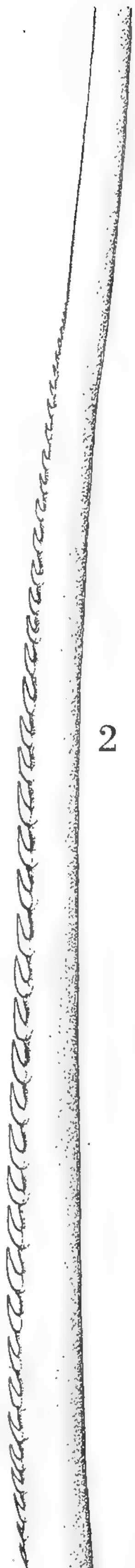

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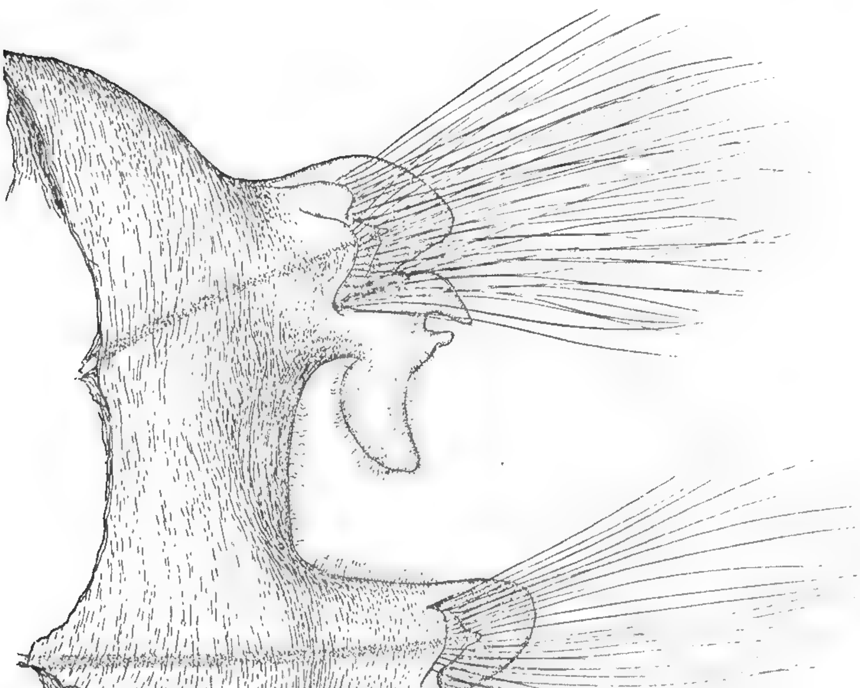

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CESTODA (TETRAPHYLLIDEA AND TRYPANORHYNCHA) FROM MARINE FISHES OF NEW SOUTH WALES

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Figs. 1-19 Manuscript received, March 23, 1964

ABSTRACT

Two new species of cestodes are described from marine fishes of New South Wales, viz., *Acanthobothrium australis* from *Squalus megalops* and *Dasyrhynchus pacificus* from *Sciaena antarctica*. In addition, *Phyllobothrium lactuca*, *Phyllobothrium dohrnii* and *Poecilancistrium caryophyllum* are recorded from Australian fishes for the first time.

INTRODUCTION

The helminth parasite fauna of Australian marine fishes is still very poorly known. This is particularly evident with regard to the cestodes, since no comprehensive taxonomic survey of these parasites has been carried out in Australian waters. References to marine fish cestodes of Australia include Haswell (1902), Johnston (1909, 1916), Drummond (1937), Crowcroft (1947), Hiscock (1954), and Williams (1962). Since the manuscript of this paper was submitted, Williams (1964) has recorded an additional six species from Australian elasmobranchs. More is known of the New Zealand cestode fauna of marine fishes as a result of the work of Robinson (1959 a, b) and Alexander (1963).

In the present report, five species (three tetraphyllideans and two trypanorhynchans) are recorded from fishes caught at various localities off the coast of southern New South Wales. One tetraphyllidean and one trypanorhynchan are described as new species and the remaining species have not been recorded previously from Australian waters.

Specimens were either collected by the author or provided by the staff of the Australian Museum. Drawings were made with the aid of a Zeiss camera lucida. All measurements are in millimetres. Type specimens are deposited in the Australian Museum collection, Sydney.

Order **Tetraphyllidea** van Beneden, 1849

Family **Phyllobothriidae** Braun, 1900

1. *Phyllobothrium lactuca* van Beneden, 1850 (Figs. 1 and 2). Host: *Mustelus antarcticus* Gunther. Locality: Kiama, N.S.W. Location: Spiral valve.

Discussion: *P. lactuca* is readily identified by the large scolex which consists of four sessile bothridia with highly convoluted margins. Proglottid anatomy, which is typical of the family, is shown in Fig. 2.

P. lactuca is the type species of the genus and one of the more familiar phyllobothriids. It has been recorded from the spiral valve of several species of *Mustelus* in European, American and Asian waters, and both Robinson (1959 a) and Alexander (1963) found this species in *M. lenticulatus* from New Zealand.

2. *Phyllobothrium dohrnii* (Oerley, 1885). (Figs. 3-5). Host: *Heptranchias dakini* Whitley. Locality: Palm Beach, N.S.W. Location: Spiral valve.

Discussion: *P. dohrnii* possesses distinctly pedunculated bothridia (Fig. 3). When worms are removed from the host and placed in physiological saline, the cup-shaped bothridia move very actively. The youngest proglottids are long and narrow with four conspicuous flaps around the posterior margin (Fig. 4). The flaps become less conspicuous in older and broader proglottids (Fig. 5).

P. dohrnii is a cosmopolitan species and is usually found in sharks belonging to the family Hexanchidae. Robinson (1959a) and Alexander (1963) recorded it from a hexanchid *Notorhynchus pectorosus* (Garman) of New Zealand and the host cited here also belongs to the Hexanchidae. It is not surprising to find *Phyllobothrium* species in primitive hosts, since Euzet (1957) regards the genus as being ancestral to many other tetraphyllideans.

Family **Onchobothriidae** Braun, 1900

3. *Acanthobothrium australis* n.sp. Host: *Squalus megalops* (Macleay). Locality: Eden, N.S.W. Location: Spiral valve.

Description: (Based on three adult specimens, one of which is mature). The entire mature specimen is 96.0 long with a maximum width of 1.1. The scolex (Figs. 6 and 7), 1.45 to 2.1 long by 1.8 to 2.6 wide, consists of four distinct, muscular, boat-shaped bothridia, each divided into 3 loculi by two muscular septa, the anterior loculus being the largest. Anteriorly, each bothridium bears a pair of hooks (Fig. 8). Each hook consists of a handle and an inner and outer prong. Anteriorly the handles overlap. The total length of the hooks varies between 0.28 and 0.30. The inner and outer prongs are of approximately equal length, i.e., about 0.140. The junction between the handle and the prongs is difficult to determine accurately. The inner prong possesses a pronounced tubercle at its base. Anterior to each pair of hooks, and forming the anterior margin of the bothridium, is a flattened, muscular accessory sucker.

The neck is short and conspicuously narrower than the scolex, with a maximum width of 0.9. Throughout the neck and strobila in stained whole mounts, the cortical, longitudinal muscle fibre bundles are particularly prominent. In the mature specimen there are about 230 proglottids. The youngest proglottids are many times broader than long, but throughout the strobila there is a gradual increase in length relative to width, so that towards the posterior end, the proglottids are slightly longer than broad. All proglottids are acraspedote.

In a mature proglottid (Fig. 9), the testes, which are arranged in two fields medial to the nerve trunks and excretory canals, number between 84 and 97 (av. 90). They are oval to rounded in shape, with a maximum diameter of 0.06. The vas deferens arises in the antero-medial region of the proglottid and coils first posteriorly then laterally to enter the cirrus pouch. Inside the cirrus pouch, the vas deferens forms a coiled ejaculatory duct which gives rise to a spined cirrus. The invaginated cirrus opens into the lateral genital atrium.

The ovary is lobulated and consists of two lateral " wings " extending anteriorly and joined posteriorly by a median narrow isthmus. Posterior to the isthmus is the shell gland from which extends the vagina, first antero-laterally, then ventral and anterior to the cirrus pouch to open into the genital atrium. The genital atrium opens marginally, in the posterior fourth of the proglottid and alternates irregularly from left to right lateral margins in succeeding proglottids. The vitellaria are small, closely packed, and arranged in two fields which are lateral to the testicular fields.

Discussion: *A. australis* is allied to other species which have been reported from sharks. It most closely resembles *A. heterodonti* Drummond, 1937, but differs from the latter in having (1) stouter hooks, each with a more strongly recurved outer prong and thicker and more irregular handle wall, (2) fewer and smaller testes, (3) more posteriorly situated genital pore.

The author wishes to thank Mr. R. McLaughlin for providing specimens of *A. heterodonti*.

Order **Trypanorhyncha** Diesing, 1863
Family **Otobothriidae** Dollfus, 1942

4. *Poecilancistrium caryophyllum* (Diesing, 1850) (Figs. 10-14). Host: *Sciaena antarctica* Castelnau. Localities: McKenzie Bay (near Bondi), N.S.W., and Richmond River, N.S.W. Location: encysted in flesh.

Description: The larval stage consists of a dense, white, globular blastocyst which contains the scolex, and a long, narrow caudal extension up to 200.0 in length. The entire larva is surrounded by a tough membrane, on the outside of which are frequently found scattered deposits of melanin. This leads to a blackened mottled appearance of the parasite. The outer membrane in several specimens undergoes branching in the musculature of the host which might be mistaken for branching of the larval tail. On removal of this outer covering membrane, however, it was observed that more than one parasite may be found within this outer cyst wall and the caudal extension of the parasite did not branch.

The scolex is released when the blastocyst is punctured. It is acraspedote, and 4.1 to 5.0 long. The bothridia are patelliform with rounded margins and strongly inclined anteriorly, i.e., the anterior margins of the two bothridia approach one another while the posterior margins are some distance apart (Fig. 10). A pair of sensory pits is present near the postero-lateral margin of each bothridium (Fig. 11).

The proboscids, up to 0.9 long, are covered with hooks. The arrangement of the hooks is heteroacanthous, in which there are rows of large hooks ascending obliquely from the mid-line of the internal surface and numerous rows of smaller hooks on the external surface (Fig. 13). Of the large hooks, hook 1 is thick with a broad base, 0.094-0.112 long; hook 2 is thinner and less curved, with a narrow base, and is 0.096 to 0.110 long. Hooks 3, 4 and 5 are progressively smaller, from 0.075 to 0.050 long. An additional hook is present between the rows of large hooks and posterior to hook 5. Small hooks covering the external surface vary in length with a maximum of 0.030.

The proboscid sheaths are weakly sinuous with a distinct loop before entering the muscular proboscid bulbs. The bulbs are 1.3 to 1.8 long by up to 0.44 wide. Posterior to the bulbs, the scolex is constricted and behind this constriction is an elongated, flattened appendix which is joined to the blastocyst by a short narrow isthmus.

Discussion: A satisfactory systematic analysis of the trypanorhynchs is hindered by many quite inadequate early descriptions, which have led frequently to extensive synonymies and many *species inquirendae.* Four species have been described and included in the genus *Poecilancistrium* by various authors, but specific differences have been concerned largely with scolex morphology. Dollfus (1942, p. 262) includes a table of measurements from various descriptions of these species which emphasises the overlapping and unsatisfactory nature of these data. Goldstein (1963) considered *Poecilancistrium caryophyllum* (Diesing, 1850) the only species in the genus reducing *P. gangeticum* (Shipley and Hornell, 1906) and *P. robustum* (Chandler, 1935) to synonymy and transferring *P. ilisha* (Southwell and Prashad, 1918) to the genus *Otobothrium* Linton, 1890.

Examination of an adult specimen of *P. caryophyllum* kindly provided by Dr. R. J. Goldstein from the lemon shark *Negaprion brevirostris* of the Gulf of Mexico, confirmed the conspecific nature of the Australian material. The dimensions of the

scolex are larger in the Australian specimens, but this does not warrant specific separation, particularly in view of Goldstein's effort to clarify the taxonomy of the genus.

The intermediate host reported here belongs to the family Sciaenidae which is consistent with previous reports from elsewhere. The known range of *P. caryophyllum* now includes Australia in addition to the Indian Ocean, the Gulf of Mexico and the Western Atlantic.

The author wishes to thank Dr. A. K. O'Gower, of the University of N.S.W., for providing specimens of *Sciaena* for examination; Mr. P. Doyle, market inspector, for collecting specimens from Richmond River, and Miss Elizabeth Pope and Dr. J. C. Yaldwyn, of the Australian Museum, for making these specimens available for study.

Family **Dasyrhynchidae** Dollfus, 1935

5. *Dasyrhynchus pacificus* n.sp. Host: *Sciaena antarctica* Castelnau. Locality: McKenzie Bay (near Bondi), N.S.W. Location: Encysted among viscera.

Description: (Based on two larval specimens). The larvae consist of a white, oval blastocyst, inside which is located the scolex, and a long, slender, whitish caudal extension (Fig. 19). Investing the larva is a tough membranous cyst wall. The scolex, 11.5 long by 1.0 wide, is weakly craspedote and only slightly enlarged in the postbulbar region. The bothridia are reversed cordiform in shape, with a distinct posterior notch.

The proboscids, up to 1.8 long by 0.15 wide, are poeciloacanthous, i.e., there is a row or " chainette " of characteristic hooks on the middle of the external surface, with oblique rows of larger hooks extending around the remainder of the proboscid on each side of the chainette. The chainette begins in the metabasal region (Fig. 17). The hooks are at first very small but increase in size rapidly as the chainette curves to the middle of the external surface of the proboscid. Midway along the length of the proboscid (Fig. 16), the hooks are almost contiguous. They have a somewhat rectangular base, rounded at the corners, and a short, sharp point. In the anterior region of the proboscid, the chainette hooks are smaller. The chainette extends along the greater part of the proboscid, and includes more than 100 hooks.

There are 10 hooks in the main oblique rows (Fig. 16). The stoutest hooks are located on the internal surface and successive hooks are thinner towards the chainette. Hook 1 is 0.080 long, hook 10 about 0.030 long. Between any two main rows there is a secondary oblique row of 6 hooks which are shorter and thinner than the hooks of the main rows.

The basal armature is distinct (Fig. 18). On the internal surface there are several stout hooks, the most posterior being the largest, up to 0.075 long, with a characteristic shape because of the fluting of the shaft near the base. Posterior to these larger hooks are two rows of narrow, smaller hooks. On the external surface of the proboscid there is an area covered with minute hooks. They are so crowded that they form an almost continuous cover. Posterior to this region there are larger more scattered hooks which, like those at the base of the opposite surface, are rounded at the tip.

The sheaths of the proboscids are distinctly coiled. No frontal glands are visible in this region of the scolex. The muscular bulbs are elongated, up to 4.9 long by 0.03 wide. The scolex is attached to the blastocyst by a thin appendix.

Discussion: *D. pacificus* differs from other species in the genus except *D. talismani* in possessing a chainette of a single rather than a double row of hooks. It differs from *D. talismani* in that the chainette extends for at least 35 rows of main hooks and includes over 100 hooks, compared with a distance equivalent to 7 rows of main hooks and only composed of about 20 hooks in *D. talismani*. The characteristic stout hooks and matted region of small hooks are not figured by Dollfus (1942) for *D. talismani*.

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EXPLANATION OF FIGURES

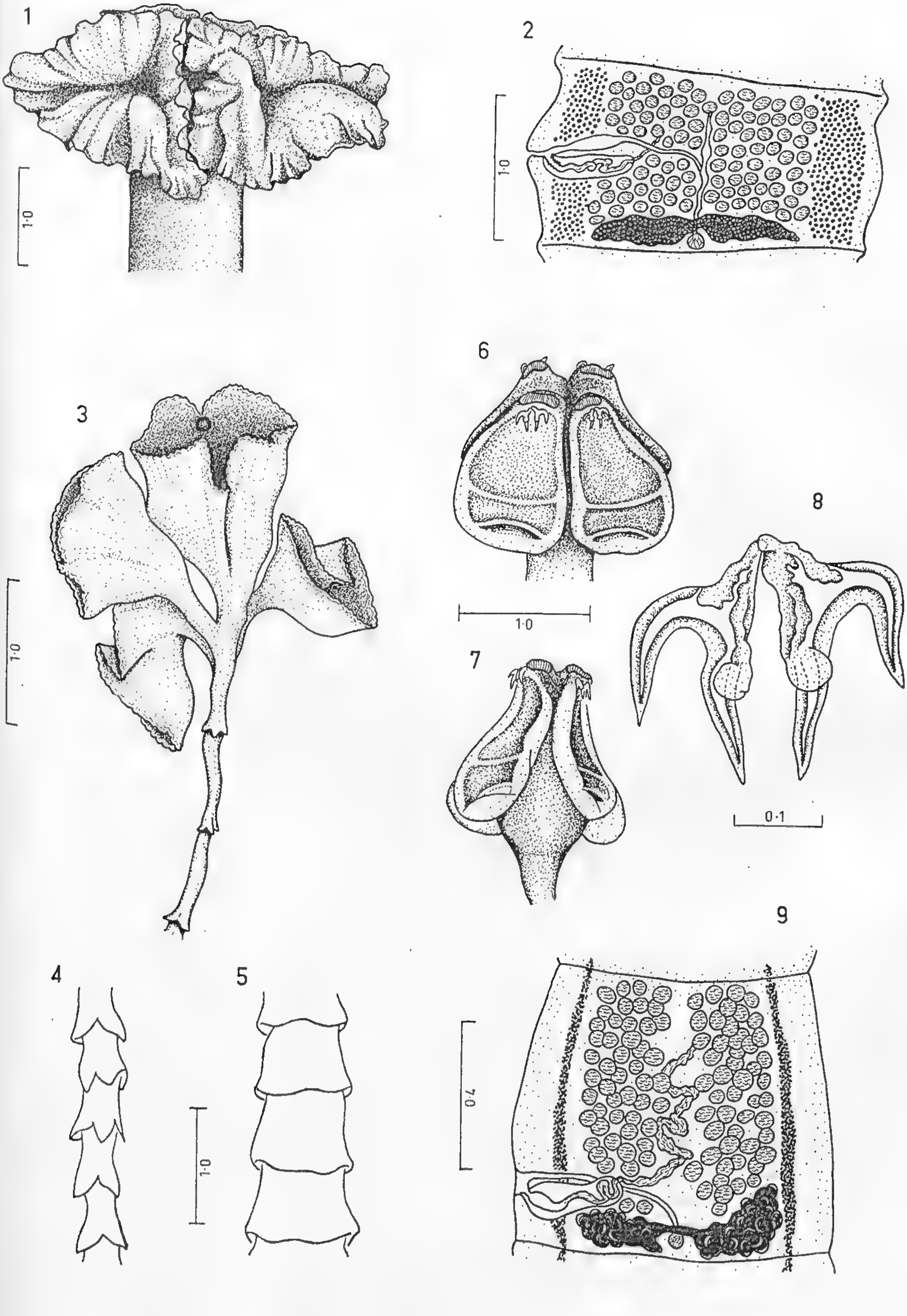
Figs. 1 and 2—*Phyllobothrium lactuca*: 1, scolex. 2, mature proglottid anatomy.

Figs. 3-5—*Phyllobothrium dohrnii:* 3, scolex. 4, young proglottids. 5, mature proglottids.

Figs. 6-9—*Acanthobothrium australis* n. sp.: scolex, bothridial view. 7, scolex, lateral view. 8, hooks. 9, mature proglottid anatomy.

Figs. 10-14—*Poecilancistrium caryophyllum:* 10, scolex, lateral view. 11, scolex, bothridial view. 12, entire larva. 13, proboscid armature. 14, large hooks.

Figs. 15-19—*Dasyrhynchus pacificus* n. sp.: 15, scolex. 16, distal proboscid armature. 17, metabasal armature. 18, basal armature. 19, entire larva.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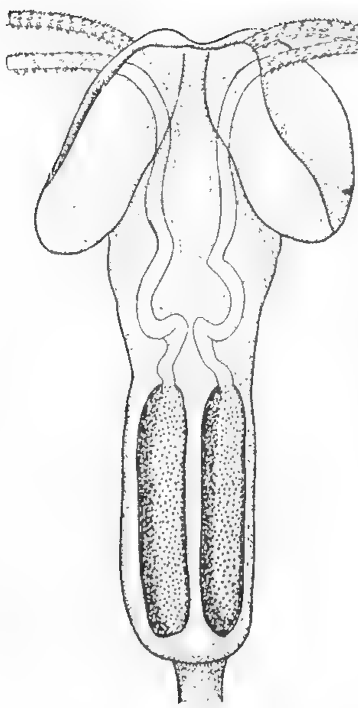

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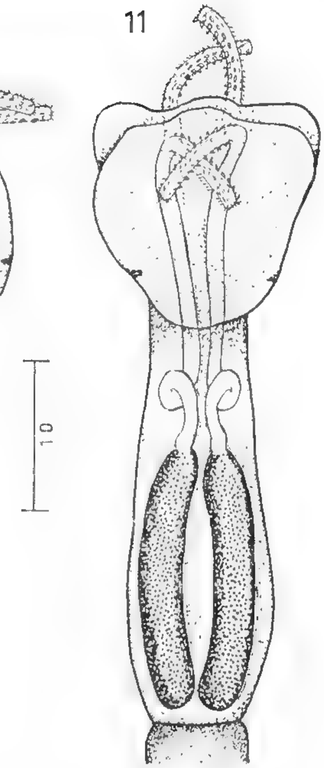

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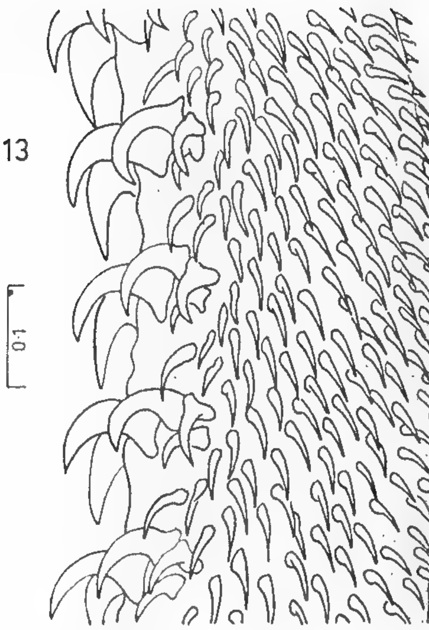

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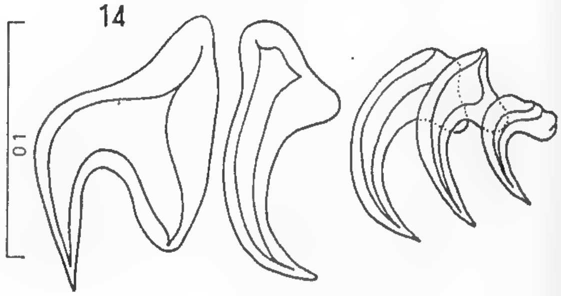

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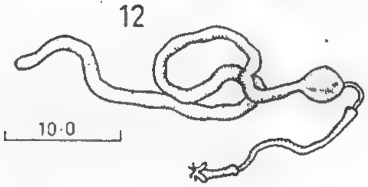

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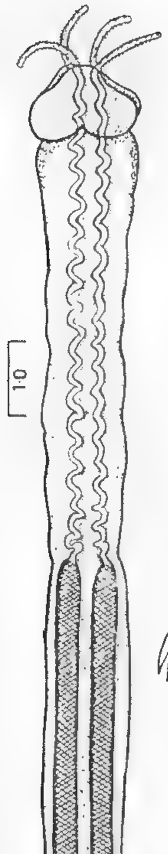

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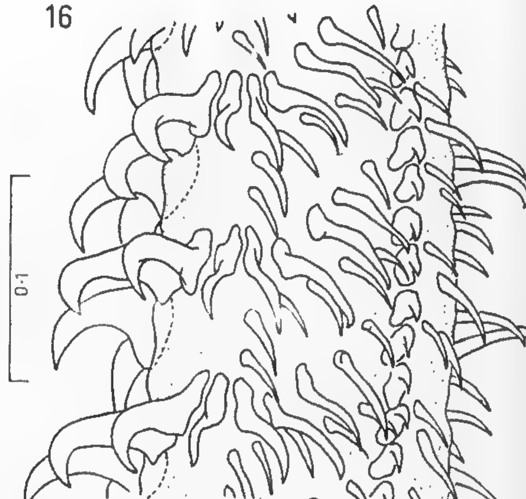

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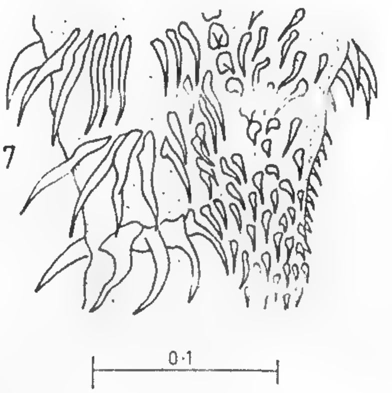

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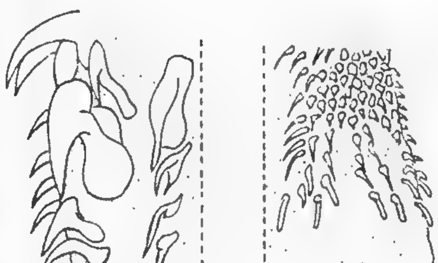

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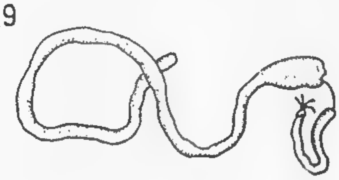

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GENERIC AND SPECIFIC DIAGNOSES IN THE GIGANTIC MACROPODID GENUS *PROCOPTODON*

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Figures 1-10 Manuscript received, June 1, 1964

ABSTRACT

A revised diagnosis of the Pleistocene genus *Procoptodon* is presented. The species also are revised and diagnosed. Numerous diagnostic characters have been found in the patterns and construction of the teeth. Owen's species *Procoptodon goliah* (Owen), 1846, *Procoptodon rapha* Owen, 1873, and *Procoptodon pusio* Owen, 1873, are recognized. As indicated by Owen, 1874, *Pachysiagon otuel* is a synonym of *Procoptodon pusio*. All of these are from late Pleistocene faunas. No specimens of *Procoptodon* are now known from older faunas. It is thought that a common ancestry of *Procoptodon* and *Sthenurus* in the Sthenurinae is much farther back in the Tertiary than has been previously assumed.

INTRODUCTION

The largest and most bulky of all kangaroos is *Procoptodon goliah*. *Procoptodon rapha*, although also large, is smaller than *P. goliah*. Other late Pleistocene macropodids like *Protemnodon* and *Macropus ferragus* have skulls of equal length but they are not as deep as in *Procoptodon*. Nor does the evidence from the limbs indicate that the other large macropodids were as large as the largest *Procoptodon* species.

Procoptodon is currently classified in the subfamily Sthenurinae. R.H. Tedford (Ph.D. dissertation), as based on his Lake Menindee specimens, has revealed that *Procoptodon* is monodactyl in the hind foot, having reduced even the fifth metatarsal to a vestige, the forelimbs are proportionally much longer than in the macropodines and the basicranium is so shortened that the skull is as deep as it is long.

The other genus of the Sthenurinae is, of course, *Sthenurus*. Tedford has in press a revision of that genus. It is our purpose here to present revised diagnoses of the genus and species of *Procoptodon*. We have recognized Owen's species *P. goliah*, *P. rapha* and *P. pusio* (syn. *Pachysiagon otuel*). Our diagnoses are based primarily on the dentition. All three species are represented in the late Pleistocene Bingara fauna which was found in Bone Camp Gully, a tributary of Ironbark Creek, 15 miles east of Bingara, New South Wales. The collection has been loaned to us from the Australian Museum for a faunal report (Marcus, Ph.D. dissertation). Our detailed information is based primarily on those specimens as compared with casts of the holotypes. It seems desirable to present the diagnoses prior to the appearance of the longer report so they will be available to others working on fossil macropodids.

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ACKNOWLEDGEMENTS

We are most grateful to Dr. John W. Evans, Director, and Harold O. Fletcher, Deputy Director of the Australian Museum, Sydney, for the privilege of describing these specimens. The plastotypes were generously supplied by Dr. A. J. Sutcliffe of the British Museum (Natural History). We also recognize with thanks the assistance of M. O. Woodburne and M. D. Plane in checking the characters with each specimen in the Bingara sample.

PROCOPTODON Owen, 1873

The genotype of *Procoptodon*, a maxilla fragment with three molars, was discovered in the Darling Downs of Queensland and presented to Richard Owen by Sir Thomas L. Mitchell in 1844. A brief preliminary description was written by Owen and was communicated to George R. Waterhouse, who at that time was writing his book on "The Natural History of the Mammalia." Consequently, Owen's first account of the specimen, which he named *Macropus goliah*, appeared with an illustration as early as 1846. Some subsequent confusion arose concerning recognition of the type specimen, because, in the original description, it was stated there were two upper molars. This evidently was an error in printing. As a result, however, Lydekker (1891) stated that the type had been lost. Fortunately this is not true. The type M1896 is in the British Museum (Natural History) and the teeth are $M^{\underline{1}}$, $M^{\underline{2}}$ and $M^{\underline{3}}$ not $M^{\underline{2}}$, $M^{\underline{3}}$ and $M^{\underline{4}}$ as recorded by Owen and Lydekker.

The generic name *Procoptodon* as well as the species names *Procoptodon rapha* and *Procoptodon pusio* were introduced in abstract form by Owen in 1873, but the specimens were fully described in his memoir in 1874. In the memoir he also described part of a mandible as *Pachysiagon otuel* which three years later (1877) he realized was a synonym of *Procoptodon pusio*. All of these types came from the Darling Downs and in so far as we know are late Pleistocene in age.

Most of the generic characters used by Owen (1874; 1876; 1877) and Lydekker (1887; 1891) are equally applicable to one or another species of *Sthenurus*. These are: large palatine vacuities extending far forward; anterior position of masseteric process; ankylosis of symphysis of mandible; deep short ramus; short canine -P_3 diastema; molars with complex enamel patterns; premolars resemble those in *Sthenurus*.

In attempting to correct Owen's identification of the specimens Lydekker (1887) incorrectly identified specimens resembling the type of *P. pusio* as *P. rapha* and used characters that are not diagnostic of the species. He also ignored Owen's (1877) earlier synonymy and used the name *Procoptodon otuel* for the lower dentitions of *P. pusio*. The specimens from Victoria that were figured by McCoy (1879) as *P. goliah* are apparently *P. rapha*.

In comparing what he considered to be transitional characters between *P. pusio* and *Sthenurus oreas*, DeVis (1895) synonymized *Procoptodon* with *Sthenurus*. Tate (1948) partly subscribed to DeVis' conclusions by recognizing *Procoptodon* and *Sthenurus* as subgenera.

The dental and mandibular characters in *P. pusio* are on the whole more like those in *Sthenurus* than are the characters in the other species of *Procoptodon*. This persuaded DeVis and others to believe that there must be an early Pleistocene or late Tertiary ancestral relationship in common for the genera. This phyletic relationship has not been confirmed in any of the older faunal assemblages. It is true, however, that we know of no *Procoptodon* specimen older than those that we have thought to be late Pleistocene in age. The presence of strong midlinks and forelinks

in the molars of *Procoptodon* and their great reduction in *Sthenurus* does not support a close relationship of the genera. Obviously these genera are more closely related than either are to any of the other genera in the Macropodidae, but if, as so frequently seems to be indicated in herbivorous mammals, the molars are less subject to accelerated evolution than the incisors, premolars, feet or gross morphology, the *Procoptodon* and *Sthenurus* lineages may well extend much farther back into the Tertiary than we can visualize on the basis of the evidence available.

Revised Generic Diagnosis: I^1 larger than I^3; I^2 small; I^3 slightly compressed laterally but not as much so nor as elongate as in *S. occidentalis;* labial surface slightly convex anteroposteriorly and without groove. P^3 more bulbous at base of crown than in all species of *Sthenurus*, except *S. occidentalis.*

Upper molars: anterior cingulum shelf less blade-like than in *Sthenurus*, anterolabial end usually not connected to base of paracone; anterior transverse valley crossed by forelink and by accessory spurs from protoloph (no forelink in *P. pusio*); high midlink sharply defined, connects anteriorly and slightly labially of anteroposterior midline across protoloph; spur from posterior surface of protoloph on midline and at lingual side of anterior part of midlink and parallel to it; no protoconal spur; area between midlink and labial end of middle transverse valley relatively narrow and not elevated; posterior paraconal spur and anterior metaconal spurs well defined in *P. goliah* and *P. rapha* but curve lingually toward midlink and sometimes connect to it, forming pockets, and do not form anteroposterior crest across labial end of middle transverse valley; in *P. pusio*, however, these spurs have strong tendency to form anteroposterior labial crest across middle transverse valley, especially on M^3 and M^4; metaconal spur as well developed or more so than in any species of *Sthenurus*; posterior surface of metaloph with vertical V-shaped grooves and adjacent ridges; transverse lophs appear less sharply crested because of prominent connection of links and spurs, relatively narrower than in *Sthenurus* and without scoop-like posterior surfaces; teeth higher crowned than in all species of *Sthenurus*, except *S. atlas.*

Mandible: horizontal ramus massive and wide transversely, lower border rounded in *P. goliah* and less sharply crested throughout its length even in *P. rapha* than in *Sthenurus;* relatively narrow digastric fossa descends from postdigastric sulcus at posterior base of ascending ramus anteroventrally to lower border of horizontal ramus below posterior end of $M_{\overline{4}}$; prominent digastric process; deep postdigastric sulcus; wide pterygoid fossa becomes narrow anteroventrally and passes below and anterior to masseteric foramen; medial angular crest passes anteroventrally where it connects with upper ridge of digastric fossa, medial surface below crest narrow and rounded; condyle and angle relatively and actually much higher above molars than in *Sthenurus.*

Lower incisor relatively smaller than in *Sthenurus*, especially in vertical depth of blade. $P_{\overline{3}}$ relatively shorter and more bulbous at base than in *Sthenurus*, except in *S. occidentalis.*

Lower molars: bulbous or tend to be bulbous at bases of crowns; anterior cingulum shelf relatively and actually wider transversely than in *Sthenurus;* high curved forelink connects transverse crest of anterior cingulum shelf with protolophid at lingual base of protoconid; small but conspicuous anterior cingulum in front of transverse crest at anterior edge of tooth; midlink high and sharply crested; prominent or subdued spur extends into middle transverse valley from hypolophid parallel and linguad to posterior part of midlink (also present in *S. oreas*); no tendency for elevation of middle area of middle transverse valley; lophids with spurs and vertical ridgelets; posterior surface of hypolophid with wide triangular grooves (except in *P. pusio*); transverse occlusal crests relatively narrower than in *Sthenurus;* lophids without scoop-like anterior surfaces; molars higher crowned than in all species of *Sthenurus*, except possibly *S. atlas.*

Procoptodon goliah (Owen), 1846

Holotype: Part of right maxilla with M^1-M^3. BMNH M1896.

Type locality: Darling Downs, Queensland.

Revised diagnosis: On the average animals slightly larger than *P. rapha;* lophs, links, spurs, ridgelets and grooves on molars not as sharply crested and on the whole less numerous on the cheekteeth than in *P. rapha*, but always more so than in *P. pusio.*

$P^{\underline{3}}$ with shorter, less sharply crested posterolabial crest than in *P. rapha;* slightly shorter than $M^{\underline{1}}$; main and lingual crest not as high and serrate as in *P. rapha;* occlusal basin open anteriorly; anterior moiety only slightly narrower than posterior moiety; base of crown bulbous posteriorly and tends to be so anteriorly.

Upper molars: crowns slightly lower and wider than in *P. rapha;* lophs slanting toward centre of crown from lingual bases (except in holotype) and some other specimens; anterior cingulum not sharply crested and closely appressed against base of anterior loph; slight emargination of link between end of cingulum and paracone on anterolabial corner of tooth; pocket on anterolabial surface of anterior loph; pocket on posterolabial surface of anterior loph and on anterolabial surface of posterior loph not opening into labial end of middle transverse valley; pit in middle transverse valley on lingual side of midlink seldom developed, but when present only on one or two upper molars (compare with *P. rapha*); posterior paraconal and anterior metaconal spurs not sharply crested, but enclose pockets; forelink less sharply crested than in *P. rapha.*

Ventral border of mandible below $M_{\overline{2}\text{-}\overline{4}}$ broadly rounded. Lower incisor relatively short and vertically wide.

$P_{\overline{3}}$ triangular in outline, with posterior moiety much wider than anterior moiety; crescentic posterolabial crest connected anterolabially and posterlingually to main crest, therefore occlusal basin closed at both ends; anterior outline as viewed from above with rounded vertical edge; slightly shorter than $M_{\overline{1}}$.

Lower molars: crowns frequently relatively wider than in *P. rapha*, lophids usually slanting toward centre of crown from lingual and labial bases; anterior transverse valley on each side of forelink tend to be shallower than in *P. rapha* or *P. pusio;* crescentic midlink directed anterolabially across middle transverse valley; protolophid spur of midlink relatively much longer than in *P. pusio;* three or more ridgelets on lingual side of midlink greatly subdued; pits in bottoms of middle transverse valley on one or both sides of midlink less frequent than in *P. rapha*, these features when present occur on one or possibly two lower molars in *P. goliah;* spur on anterior surface of hypolophid at lingual side of midlink and parallel to it well developed; pocket not formed on posterior surface of protolophid on lingual side of midlink; three prominent ridges and two wide grooves on posterior surface of hypolophid.

Procoptodon rapha Owen, 1873

Holotype: Part of immature left mandible with base of incisor, diastema from I-$P_{\overline{2}}$, roots and alveoli of $P_{\overline{2}}$ and $DP_{\overline{3}}$, $P_{\overline{3}}$ unerupted. BMNH 32885.

Type locality: Condamine River, Darling Downs, Queensland.

Revised diagnosis: On the average animals slightly smaller than *P. goliah*; lophs, links, spurs, ridgelets and grooves on molars sharper crested and on the whole more numerous on the cheekteeth than in *P. goliah*, and always more than in *P. pusio.*

P^3 with prominent, sharp, posterior labial, crescentic crest; slightly longer than M^1; main crest and lingual crest high and serrate; occlusal basin open anteriorly; anterior moiety much narrower than posterior moiety; base of crown bulbous posteriorly but less so anteriorly.

Upper molars: crowns slightly higher and narrower than in *P. goliah*; crowns nearly vertical at lingual ends of lophs; anterior cingulum sharply crested and projected anteroventrally; deep emargination of link between end of cingulum and paracone on anterolabial corner of tooth; pocket on anterolabial surface of anterior loph; pocket on posterolabial surface of anterior loph and on anterolabial surface of posterior loph usually open into labial end of transverse valley; pit formed on all four upper molars in middle transverse valley between base of midlink and low ridge which is half-way between midlink and lingual mouth of valley (this low ridge not to be confused with midline protoloph spur that is parallel and on same level as anterior part of midlink); posterior paraconal and anterior metaconal spurs sharply crested, but seldom enclose pockets; forelink more sharply crested than in *P. goliah.*

Ventral border of mandible below M_{2-4} rather sharply defined vertically. Lower incisor relatively short and vertically wide.

P_3 triangular in outline, with posterior moiety much wider than anterior moeity; crescentic posterolabial crest separated from main crest anterolabially and posterolingually, therefore occlusal basin open at both ends; anterior outline as viewed from above with rather sharp vertical edge; slightly shorter than M_1.

Lower molars: crowns relatively narrower than in *P. goliah*; nearly vertical at labial and lingual ends of lophids; anterior transverse valley on each side of forelink deeper than in *P. goliah*; midlink usually directed anterolabially across middle transverse valley; protolophid spur of midlink relatively much longer than in *P. pusio*; three or more ridgelets on lingual side of midlink usually more prominent than in *P. goliah*; pits in bottom of middle transverse valley on one or both sides of midlink more frequent than in *P. goliah*—these features on all lower molars in *P. rapha*; spur on anterior surface of hypolophid at lingual side of midlink and parallel to it well developed; pocket formed on posterior surface of protolophid on lingual side of midlink; three prominent ridges and two grooves on posterior surface of hypolophid.

Procoptodon pusio Owen, 1873

Synonym—**Pachysiagon otuel** Owen, 1874

Holotype: Pair of maxillae with P^3 unerupted, DP^3, M^1-M^3, most of right M^1 now destroyed as well as labial side of anterior cingulum of left M^1. BMNH 39996.

Type locality: King Creek, Darling Downs, Queensland.

Revised diagnosis: Animals much smaller than *P. goliah* or *P. rapha*; lophs, links, spurs, ridgelets and grooves on molars greatly reduced in numbers and not sharply crested.

P^3 with or without slight indication of posterolabial crest; slightly shorter than M^1; main crest high and sharply crested but not as serrate as in *P. goliah* or *P. rapha,* lingual crest lower and also less serrate; occlusal basin closed anteriorly; anterior moiety much narrower than posterior moiety; base of crown somewhat bulbous posteriorly and less so anteriorly.

Upper molars: crowns nearly vertical at lingual ends of lophs; posterior labial paraconal and anterior labial metaconal spurs with strong tendency to form anteroposterior labial crest across middle transverse valley especially on $M^{\underline{3}}$ and $M^{\underline{4}}$, posterior paraconal spur also connects across to midlink forming smaller anterior pocket, this connection then forms anterior border of larger posterior pocket that encloses labial third of middle transverse valley (although these features do not occur in the holotype); pocket on posterior surface of metaloph present or absent; no pocket formed on anterolabial surface of anterior loph; no forelink; no pit in middle transverse valley at lingual base of midlink.

Ventral border of mandible below $M_{\overline{2}\text{-}\overline{4}}$ inflected and sharply defined on lingual edge of ramus. Lower incisor relatively long and vertically narrower than in *P. goliah.*

$P_{\overline{3}}$ elongate with posterior moiety only slightly wider than anterior moiety; relatively short crescentic posterolabial crest separated from main crest anterolabially and posterolingually by narrow clefts similar to *P. rapha,* occlusal basin relatively short; anterior outline as viewed from above with rather rounded vertical edge; much shorter than $M_{\overline{1}}$.

Lower molars: crowns relatively narrow, nearly vertical at lingual and labial ends of lophids; anterior transverse valley on each side of forelink deeper than in *P. goliah*; midlink directed anterolingually then anterolabially across middle transverse valley in early stages of wear and nearly straight in later stages; protolophid spur of midlink relatively much shorter than in *P. goliah* or *P. rapha*; one to three ridgelets on lingual side of midlink more reduced than in *P. rapha*; no pits in bottom of middle transverse valley on lingual side of midlink; spur on anterior surface of hypolophid at lingual side of midlink and parallel to it only slightly developed; pocket not formed on posterior surface of protolophid on lingual side of midlink; posterior surface of hypolophid with numerous small ridgelets and shallow grooves, area slightly depressed, short but more prominent ridgelet at middle near base of crown.

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EXPLANATION OF FIGURES

Fig. 1. *Procoptodon pusio* Owen, 1873; holotype, Darling Downs, Qld.; *a*, occlusal view of left P^3, twice natural size; *b*, occlusal view of left DP^3 and M^1 — M^2 in maxilla, natural size, partly redrawn from Owen 1874 (Pl. LXXVII, 6) and 1877 (Pl. XC, 6); BMNH 39996.

Fig. 2. *Procoptodon rapha* Owen, 1873; referred specimen, Bingara fauna, N.S.W.; occlusal views of P^3 — M^1, natural size; Aust. Mus. MF1048.

Fig. 3. *Procoptodon goliah* (Owen), 1846; holotype, Darling Downs, Qld.; *a*, occlusal views of right M^1 — M^3 in maxilla; *b*, M^3, posterior view; natural size; drawn from cast; BMNH M1896.

Fig. 4. *Procoptodon goliah* (Owen), 1846; referred specimen, Bingara fauna, N.S.W., *a*, occlusal views of left P^3, M^1 — M^2 in maxilla; *b*, M^3, posterior view; natural size; Aust. Mus. MF890.

Fig. 5. *Procoptodon rapha* Owen, 1873; holotype, Condamine River, Darling Downs, Qld.; *a*, labial view showing base of incisor, diastema and unerupted P_3, natural size; *b*, occlusal view, and *c*, labial view of P_3; natural size; drawn from cast; BMNH 32885.

Fig. 6. *Procoptodon pusio* Owen, 1873; holotype of *Pachysiagon otuel*, King Creek, Darling Downs, Qld.; part of right mandible with occlusal view of M_2 — M_4; natural size; drawn from cast; BMNH 46310.

Fig. 7. *Procoptodon pusio* Owen, 1873; referred specimen, Bingara fauna, N.S.W.; *a*, occlusal and *b*, labial views of right P_3; twice natural size; drawn from nearly complete mandible; UCMP 60053.

Fig. 8. *Procoptodon pusio* Owen, 1873; referred specimen, Bingara fauna, N.S.W.; left mandible with occlusal views of P_3, M_1 — M_4, diastema partly restored; natural size; UCMP 60053.

Fig. 9. *Procoptodon rapha* Owen, 1873; referred specimen, Bingara fauna, N.S.W.; left mandible with occlusal views of P_3, M_1 missing, M_2 — M_4; natural size; Aust. Mus. MF886.

Fig. 10. *Procoptodon goliah* (Owen), 1846; referred specimen, Bingara fauna N.S.W.; right mandible with occlusal views of P_3, M_1 missing, M_2 — M_4 (drawn in reverse); natural size; Aust. Mus. MF953.

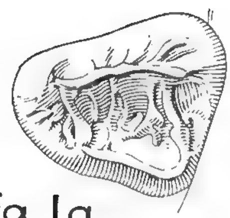

Fig. 1a

Fig. 1b

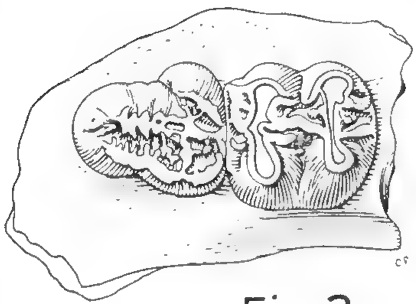

Fig. 2

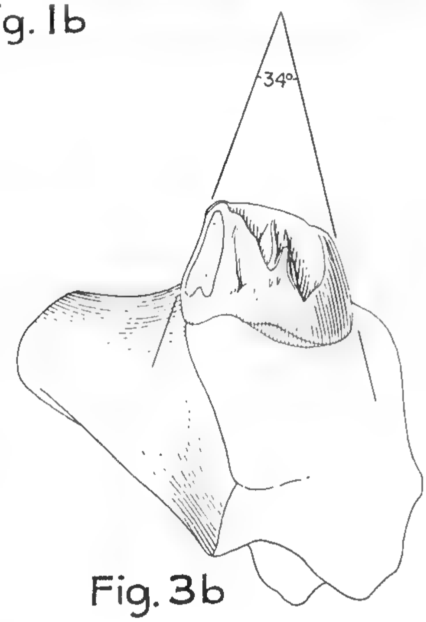

Fig. 3b

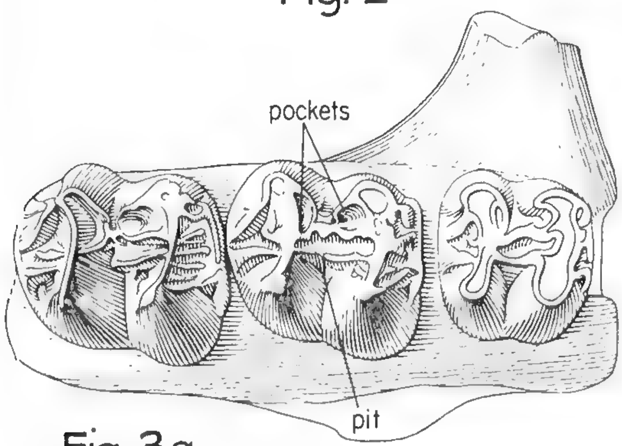

Fig. 3a

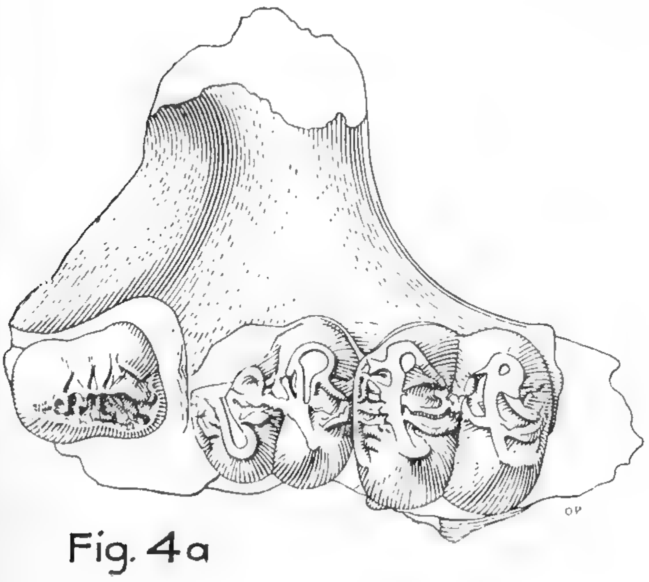

Fig. 4a

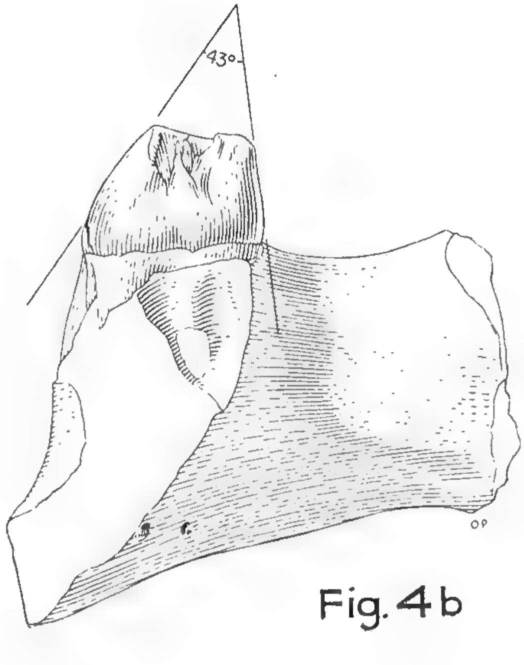

Fig. 4b

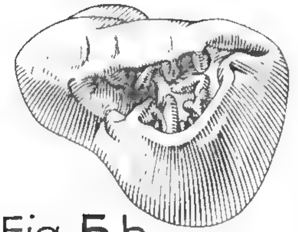

Fig. 5 b

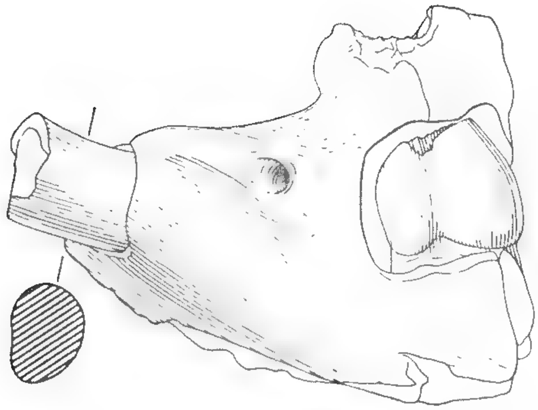

Fig. 5a

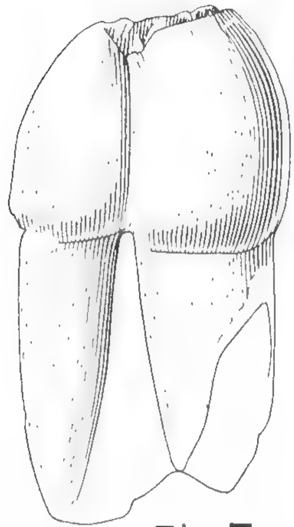

Fig. 5c

Fig. 6

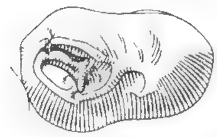

Fig. 7a

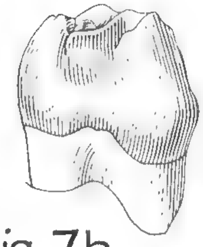

Fig. 7b

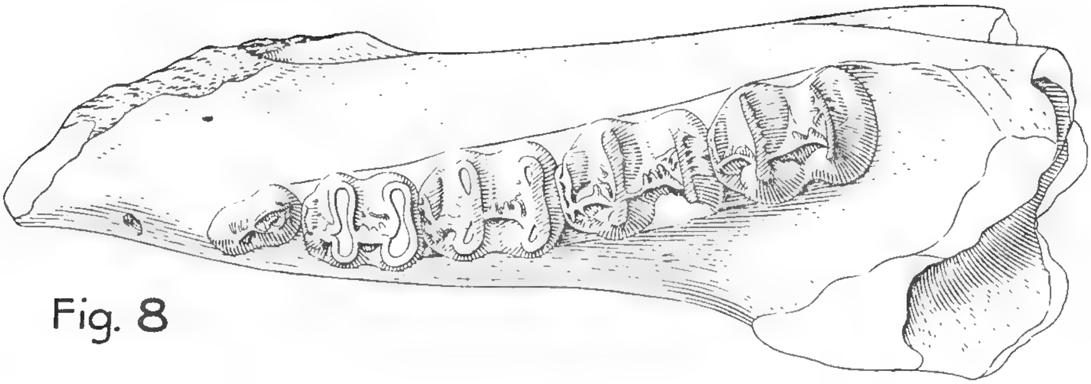

Fig. 8

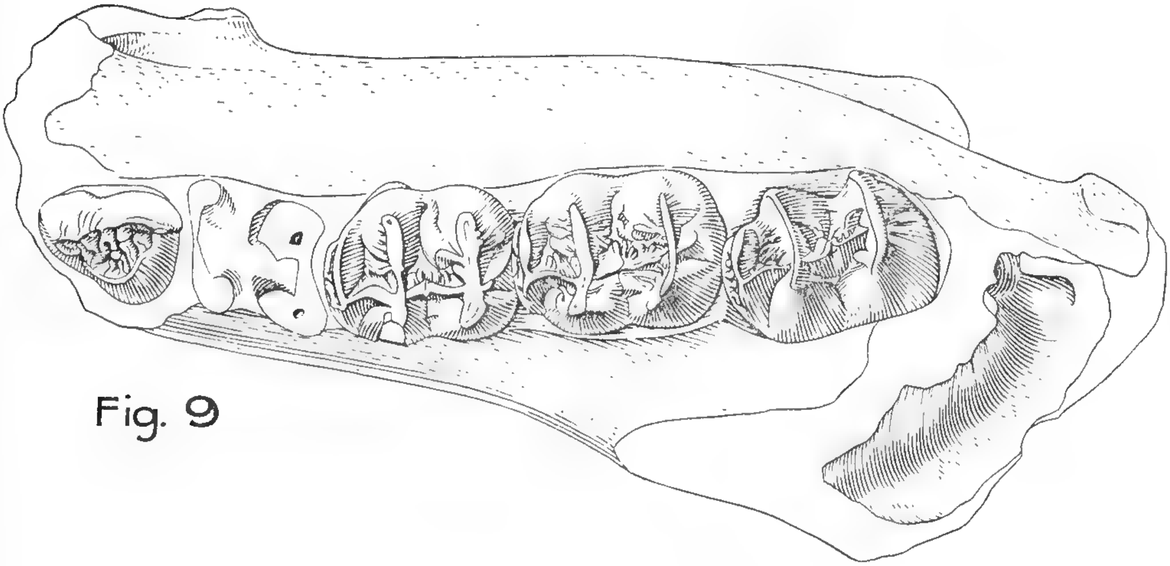

Fig. 9

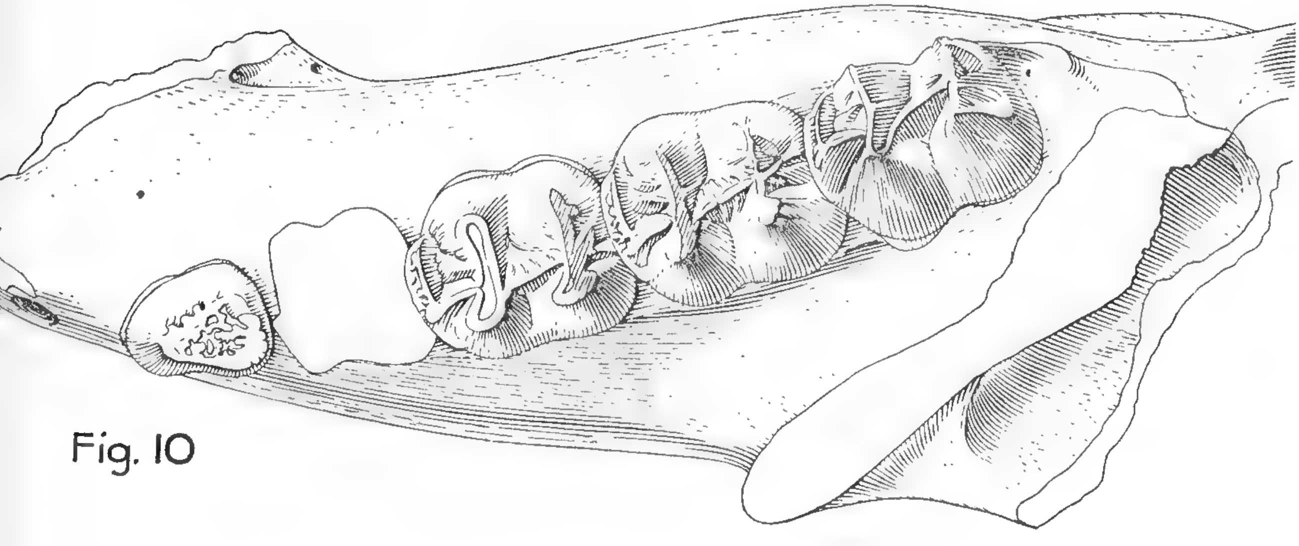

Fig. 10

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NEW RECORDS OF SOME LITTLE KNOWN AUSTRALIAN POLYCHAETOUS ANNELIDS

By OLGA HARTMAN*

Allan Hancock Foundation, University of Southern California, U.S.A.

Plates 36-38. Fig. 1 Manuscript received, July 10, 1964

The four species named below were sent to the Allan Hancock Foundation by Miss Elizabeth Pope, Curator of Worms and Echinoderms at the Australian Museum, Sydney, New South Wales. I am indebted to Miss Pope for the privilege of examining these interesting animals. Mr. Carl Petterson, scientific illustrator, prepared the plates of photographs and figures. I am grateful to the Administration of the Allan Hancock Foundation of the University of Southern California for support and the use of physical facilities. The specimens are deposited in the Australian Museum, Sydney.

Family **POLYODONTIDAE** Pflugfelder

Genus **Polyodontes** Audouin and Milne Edwards, 1832

Polyodontes australiensis (McIntosh) 1885

Plate 36 a, b

Eupompe australiensis McIntosh, 1885, pp. 135-139, pl. XXI, figs. 4, 5, pl. XXIII fig. 8, pl. XXIV, fig. 4, pl. XXXIA, figs. 2-6.

Polyodontes australiensis Hartman, 1939, p. 82.

New records: The Basin, Pittwater, Port Jackson, New South Wales.

Diagnosis: A large, posteriorly incomplete specimen measures 150 mm. long by 20 mm. wide and retains about 90 setigerous segments. The species was first described from a fragment measuring 50 mm. long and 24 mm. wide, thus a comparably large individual. The body (pl. 36 a) is thickest in the anterior region between setigers 10 to 20 where it is dorsally arched. The ventrum (pl. 36 b) is nearly flat, and behind segment 40 to 50 the body is depressed. Elytra are large and limited to the sides; they do not cover the dorsum. The prostomium has a pair of prominent eyestalks. The species was referred to *Polyodontes* because the superior neuropodial setae are distally hastate and not penicillate (Hartman, 1939, p. 81).

The present specimen agrees well with the original account of McIntosh (1885, p. 135). The species has remained unreported since first taken by the Challenger Expedition, off Cape York, Torres Strait.

Distribution: New South Wales, Queensland, Australia.

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* Contribution No. 278 of the Allan Hancock Foundation, University of Southern California.

Family **SYLLIDAE** Grube

Genus **Myrianida** Milne Edwards, 1845

Myrianida pachycerus (Augener) 1913, new combination

Fig. 1 a, b

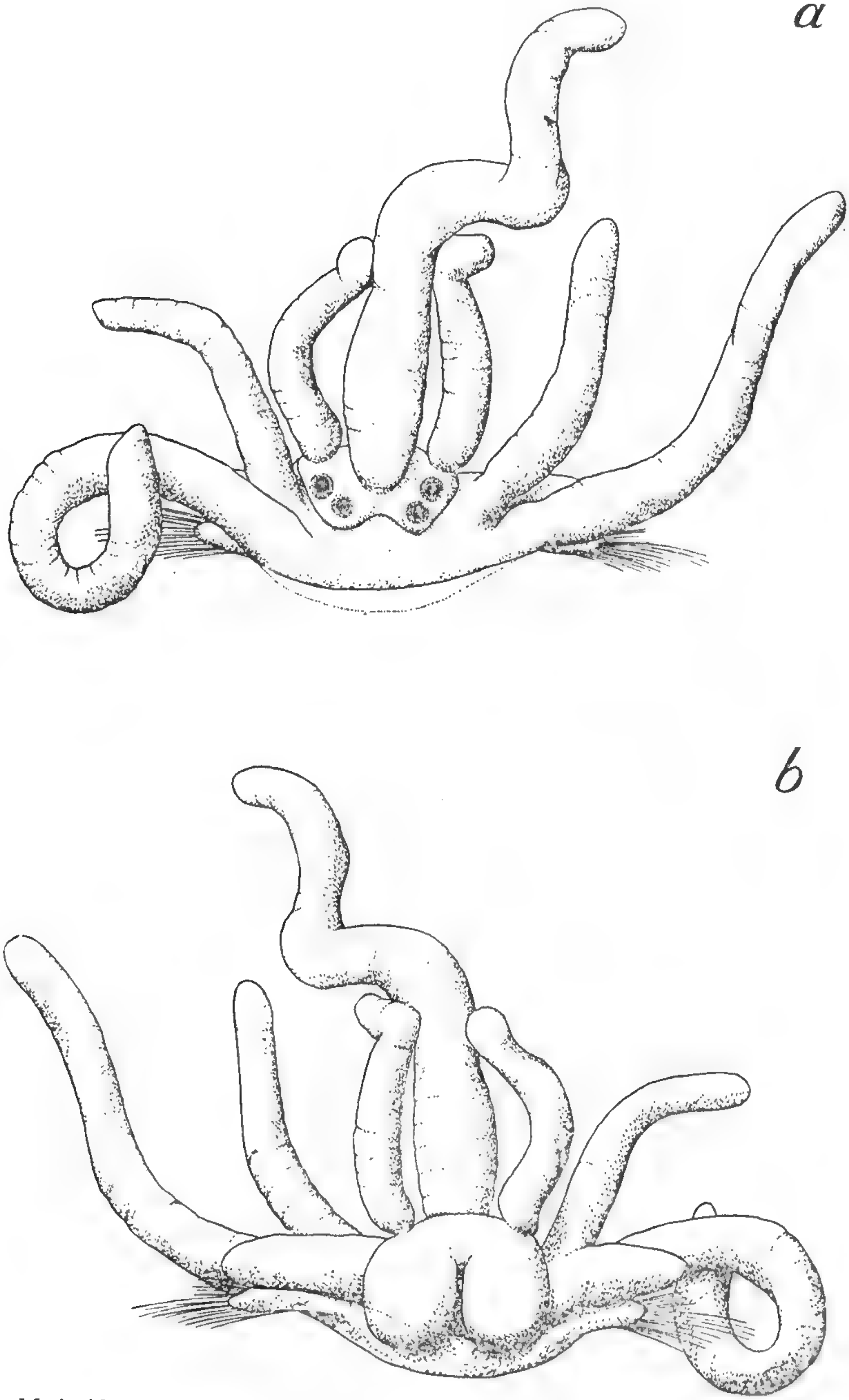

Fig. 1 a, b: *Myrianida pachycerus* (Augener) 1913; a, anterior end, in dorsal view, x 120; b, anterior end, in ventral view, x 120.

Autolytus pachycerus Augener, 1913, pp. 257-260, pl. II, figs. 11 a-12, text fig. 40 a-c.

New Record: Long Reef, New South Wales, in weed-mat, intertidal, August 4, 1962.

Diagnosis: In life the stock, without stolons, is about 5 mm. long and 0.5 mm. wide. The stock with 50 segments is accompanied by smaller, slenderer stolons numbering 10 to 15 in a chain; together they are nearly as long as, or somewhat longer than, the stock region; each consists of about 30 segments. Colours in life (noted by Miss Pope) consist of a bright blue or purple spot, usually round but sometimes a transverse streak, on the mid-dorsum of each segment; the ground colour is orange. Preserved specimens have no colour pattern.

The prostomial lobe is wider than long and slightly emarginate at its posterior end; it lacks epaulettes. It has long, thick antennae; the median antenna is thickest and is inserted between the anterior prostomial eyes; the paired lateral antennae are much smaller. The tentacular cirri (fig. 1 a) are very similar to the antennae; the two dorsal cirri are longer than the two ventral ones. Four eyes are present in trapezoidal arrangement, with the anterior pair wider apart. The paired palpi (fig. 1 b) are thick, subglobular and to be seen only in ventral view. The pharynx, seen through the body wall, terminates distally in a circlet of larger teeth alternating regularly with three much smaller denticles. The proventriculus extends through segment 7/8 or 8/9.

Parapodia are short and blunt throughout. Dorsal cirri are long and digitiform as originally shown (Augener, 1913, fig. 4 c). Setae are of two kinds: a single, superior seta is simple and very slender; it is accompanied by a transverse fascicle of 23 or more thicker, shorter, composite falcigers; each of these has an appendage about twice as long as wide, and the distal end is unequally bifid, with the larger tooth at an oblique angle to the shaft and the distal tooth nearly in line with it; the cutting edge of both appendage and shaft is denticulate.

This is referred to *Myrianida* because dorsal cirri are thick and digitiform, instead of slender and filiform; the stock gives rise to many, instead of a few, stolons.

Distribution: New South Wales; Western Australia, in intertidal or shallow depths.

Family **PECTINARIIDAE** Quatrefages

Genus **Amphictene** Savigny, 1818

Amphictene crassa Grube, 1870

Plate 37 a, b

Pectinaria crassa Grube, pp. 321-322.

Pectinaria (*Amphictene*) *crassa* Nilsson, 1928, pp. 58-64, figs. 18, 19.

New record: Specific locality not known; received from Sydney, New South Wales, August, 1963.

Diagnosis: The body is thick, plump and measures to 70 mm. long; it is widest at the fourth segment where it measures 15 to 20 mm. across, and it tapers posteriorly to a width of 10 mm. Colour (preserved) is pearl grey. Both dorsum and ventrum have fine transverse stripes (retained in alcohol). There are 16 segments with flattened setal fascicles; the first three and the last two pairs project little from the parapodia. The anterior margin of the cephalic lobe has 32 cirriform appendages

and the posterior fold of this lobe, which is about twice as broad as long, terminates in 56 triangular lobes. Twelve pairs of gold-coloured spines are directed forward; they are conspicuous and terminate distally to slender points. The lateral cirrus of the first segment at the outermost ends of paleae is shorter and slenderer than that of the second segment.

Branchiae are brown, measure about 7 mm. long, and numerous. Uncini are broad, the cutting edge of each has 8 to 10 teeth. Uncinial tori number 13 pairs; the first are present from the fourth setiger. The tube (pl. 37 a) is thin-walled, fragile, externally covered with white, smooth, platy-pebbles about 3 mm. across, and a few dark ones; it measures about 37 mm. long and 16 mm. wide at its anterior end and 14 mm. at the posterior, narrower end. Internally (pl. 37 b) it is lined with a thin, translucent membrane which retains its form even though the pebbles are broken away.

The scapha at the posterior end is approximately six-sided; it measures 4.5 mm. long by 6 mm. wide.

The species has been redescribed by Nilsson (1928) based on specimens from Palau.

Distribution: New Caledonia; Trincomali, Ceylon; Palau; questionably New South Wales.

Family **TEREBELLIDAE** Malmgren

Genus **Loimia** Malmgren, 1866

Loimia nr. **ingens** (Grube) 1878

Plate 38 a, b

Terebella ingens (Grube) 1878, pp. 228-230, pl. XIII, fig. 1.

Loimia ingens Hessle, 1917, p. 170.

New record: Long Reef, Collaroy, Sydney, New South Wales, under boulder, collected October 6, 1963, by Miss Isobel Bennett.

Diagnosis: This is the largest of all *Loimia* species; it measures 310 to 506 mm. long, of which the thorax comprises nearly one-third of the total length; the cephalic region (pl. 38 a) is relatively short. Greatest width is at segments 12 to 13, where the body is about 16 mm. wide; it tapers posteriorly to a blunt end. The thorax consists of 17 setigerous segments and the abdomen of many more. Lateral lappets (pl. 38 b) are conspicuous in the branchial region. Branchiae number three pairs with the first pair the largest; all are dendritically branched and have thick, basal trunks. Thoracic notopodia are present from segment 4; the setae are smooth and limbate. Uncini are present from the second setiger; they are pectinate, with the teeth in a single row; the first uncini in the first segment have only three or four marginal teeth each, with the basal tooth always the largest, and decreasing in size distally. The specific identity is questioned because the number of uncinial teeth varies between three to five.

Distribution: Sydney, New South Wales; Bohol, Philippine Islands.

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EXPLANATION OF PLATES

Plate 36 a, b, *Polyodontes australiensis* (McIntosh) 1885: a, entire animal, in dorsal view, x 1. b, entire animal, in ventral view, x 1.

Plate 37 a, b, *Amphictene crassa* (Grube), 1870: a, tube and entire animal, the tube seen from the outside, and animal in dorsal view, slightly enlarged. b, tube and entire animal, the tube seen from the interior, and the animal in ventral view, slightly enlarged.

Plate 38 a, b, *Loimia* nr. *ingens* (Grube) 1878: a, entire animal, in right lateral view, slightly enlarged. b, entire animal, in left lateral view, showing distal ends of branchiae, slightly enlarged.

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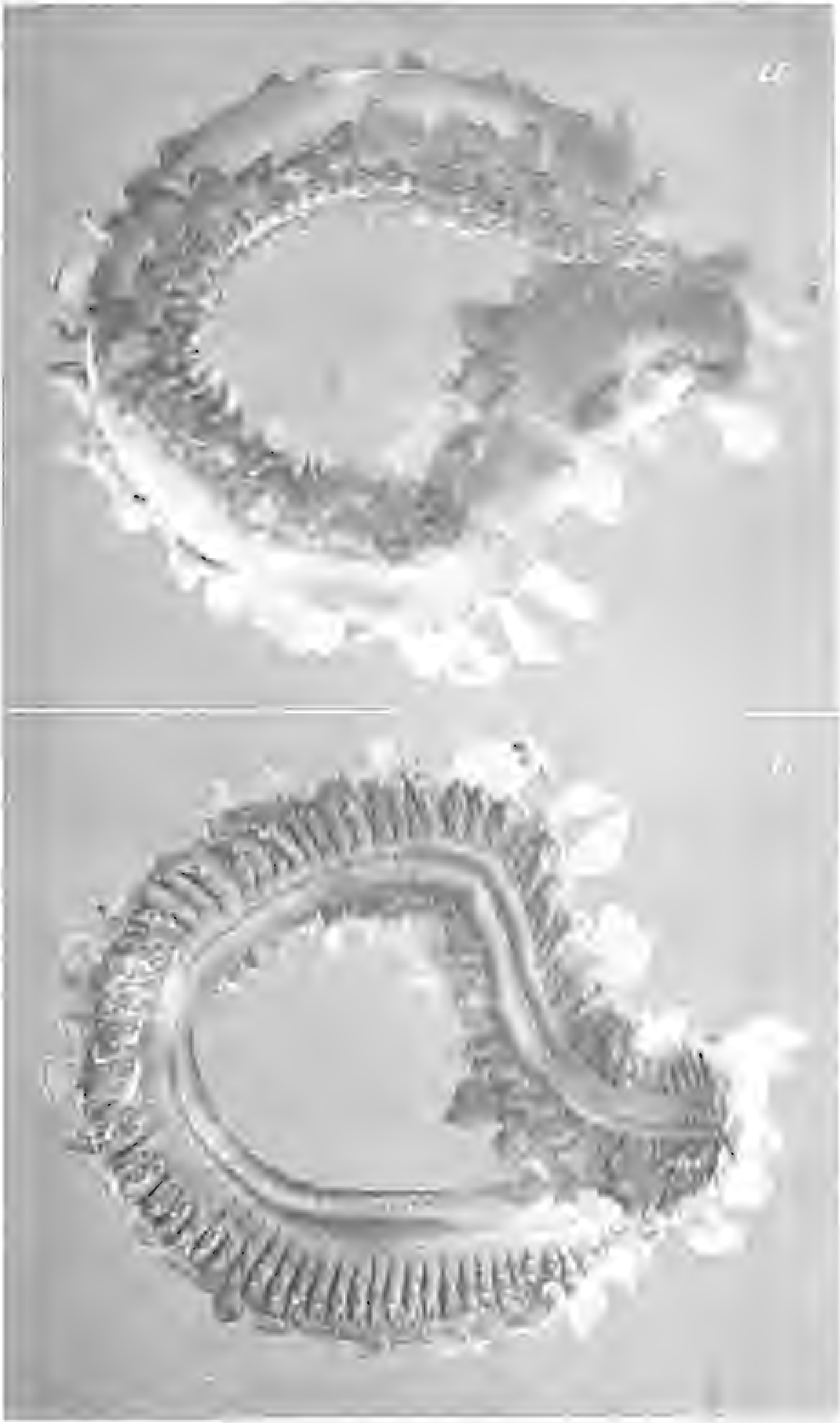

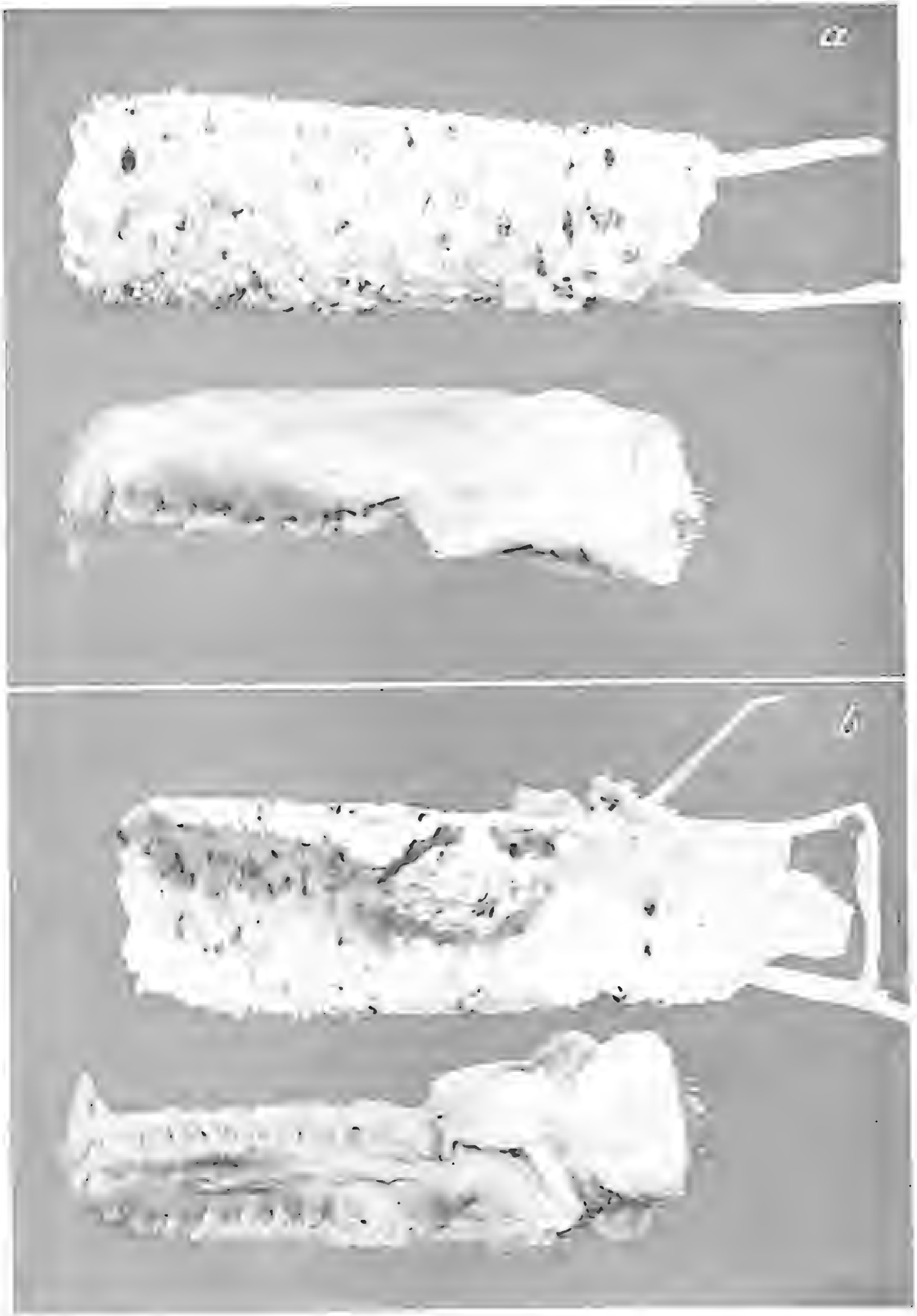
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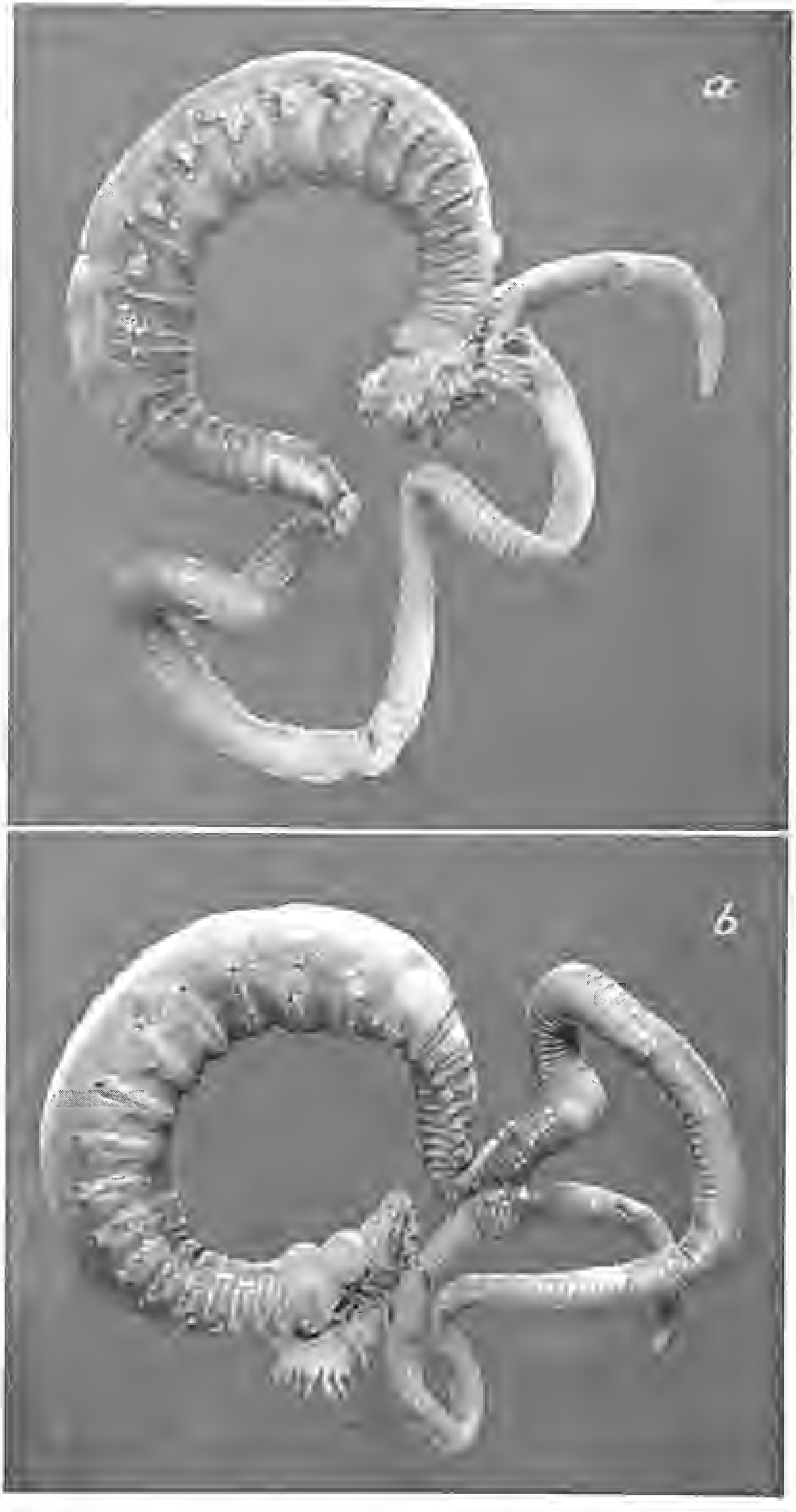
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